# LATVIA'S
# NATIONAL INVENTORY REPORT

## Submission under UNFCCC and the Kyoto Protocol

### Common Reporting Formats (CRF)

### 1990 – 2014

2016

# PREFACE

Latvia's National Inventory under the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC contains following parts:

1. Latvia's National Inventory Report is prepared using the reporting guidelines of UNFCCC (adopted by decision 24/CP.19) and relevant parts of the Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol;

2. CRF (Common Reporting Format) data tables for years 1990-2014 including KP-LULUCF data tables. The CRF tables are compiled with the UNFCCC CRF Reporter software (version 5.14);

3. SEF (Standard Electronic Tables) for reporting of Kyoto units (AAU, ERU, CER, t-CER, l-CER, RMU) in the registry. SEF tables are provided separately for units relevant to the first commitment period (SEF tables for 2015) and for units relevant to the second commitment period (SEF tables for 2014 and 2015).

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The Latvia's National Inventory Report as well as the CRF tables can be downloaded from address: http://www.meteo.lv/

# DISCLAIMER

According to Decision 13/CP.20 of the Conference of the Parties to the UNFCCC, the CRF Reporter version 5.0.0 was not functioning in order to enable Annex I Parties to submit their CRF tables. In the same Decision, the Conference of the Parties reiterated that Annex I Parties may submit their CRF tables after April 15 2015, but no longer than the corresponding delay in the CRF Reporter availability. Decisions 20/CP.21 and 10/CMP.11 further noted that the CRF reporter was still not functioning.

"Functioning" software means that the data on the greenhouse emissions/removals are reported accurately both in terms of reporting format tables and XML format. The CRF reporter version 5.12.0, released on 27th November 2015, as well as its subsequent hotfixes, still contain issues in the reporting format tables and XML formats, in particular in relation to Kyoto Protocol requirements, and cannot therefore be considered yet as functioning to allow submission of all the information required under Kyoto Protocol.

In 2015 Latvia made an inventory submission under UNFCCC, but not under Kyoto Protocol because the CRF Reporter could not deliver CRF tables for Kyoto Protocol LULUCF activities without errors. The present report is the official inventory submission of Latvia for the year 2016 under the UNFCCC and for the years 2015 and 2016 under the Kyoto Protocol in spite of the remaining deficiencies in the CRF Reporter and underlying CRF tables. Latvia should not be held liable for errors caused by the CRF Reporter in the review of the submitted information. The inventory data reported in the 2015 submission under the UNFCCC have been revised in this submission. Therefore, the 2016 submission should also be considered as a resubmission of the estimates with regard to the 2015 UNFCCC submission.

The CRF Reporter still contains several issues regarding the information required under Kyoto Protocol. For example, it is not possible to make the choice of accounting annually or at the end of the commitment period. Also there are errors and display issues in most sectors. These errors concern data that do not affect the calculation of the total national emissions.

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# UNITS AND ABBREVIATIONS

| | |
|---|---|
| t | 1 tonne (metric) = 1 megagram (Mg) = $10^6$ g |
| Mg | 1 megagram = $10^6$ g = 1 tonne (t) |
| kt | 1 gigagram = $10^9$ g = 1 kilotonne (kt) |
| Tg | 1 teragram = $10^{12}$ g = 1 megatonne (Mt) |
| TJ | 1 terajoule = 1000 Gigajoule = $10^{12}$ J |

**AAU** – Assigned Amount Units
**AR** – Afforestation and reforestation
**AWMS** - Animal waste management systems
**CER** – Certified Emission Reduction Units
**$CH_4$** – Methane
**CIS** – Commonwealth of Independent States
**$CO_2$** – Carbon dioxide
**$CO_2$ eq.** – Carbon dioxide equivalent
**CO** – Carbon monoxide
**CR** – Corinair emission factor
**CRF** – Common Reporting Format
**CS** – Country specific
**CSB** – Central Statistical Bureau
**D** – Default emission factor
**EMEP/CORINAIR 2007** – Atmospheric emission inventory guidebook, Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe, The Core inventory of air emissions in Europe
**EMEP/EEA 2013** - EMEP/EEA air pollutant emission inventory guidebook 2013
**EU** – European Union
**EU ETS** – European Union Emission Trading Scheme
**EU MMR** – European Union Monitoring Mechanism Regulation
**EU ESD** – European Union Effort Sharing Decision
**ERT** – Expert review team
**ERU** – Emission Reduction Units
**ETR** – Emission trading registry
**GHG** – Greenhouse Gases
**GDP** – Gross domestic product
**HFC** – Hydrofluorocarbon
**HWP** – Harvested wood products
**FM** – Forest management
**FMRL** – Forest Management Reference Level
**IE** – Included elsewhere
**IPCC** – Intergovernmental Panel on Climate Change
**IPCC 1996** – Revised 1996 IPCC Guidelines for National Greenhouse gas Inventories (1997)
**IPCC GPG 2000** - IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)
**IPCC GPG LULUCF 2003** – IPCC Good Practice Guidance for land Use, Land – Use Change and Forestry (2003)

**2006 IPCC GUIDELINES** – 2006 IPCC Guidelines for National Greenhouse Gas Inventories
**IPCC WETLANDS SUPPLEMENT -** 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands
**IPCC KP SUPPLEMENT** - 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol
**IPE** – Institute of Physical Energetics
**IPPC** - Integrated Pollution Prevention Control
**l-CER** – Long term Certified Emission Reduction Unit
**LEGMC** – Latvian Environment, Geology and Meteorology Centre
**LSIAE** – Latvian State Institute of Agrarian Economics
**LULUCF** – Land Use, Land Use Change and Forestry
**MoA** - Ministry of Agriculture of the Republic of Latvia
**MEPRD** - Ministry of Environmental Protection and Regional Development of the Republic of Latvia
**MoT** - Ministry of Transport
**MMS** – Manure management system
**NFI** – National forest inventory
**$NF_3$** – Nitrogen trifluoride
**$N_2O$** – Nitrous oxide
**NOx** – Nitrogen oxides
**NA** – Not applicable
**NCV** – Net calorific value
**NE** – Not estimated
**NIR** – National inventory report
**NMVOC** - Non-methane volatile organic compounds
**NO** – Not occuring in Latvia
**OECD** - Organisation for Economic Co-operation and Development
**PFC** – Perfluorocarbon
**REB** – Regional Environment Boards
**RMU** – Removal Units
**RTSD** – Road Traffic Safety Department
**SAM** – State Agency of Medicines of the Republic of Latvia
**SEF** – Standart Electronic Format
**SFRS** – State Firefighting & Rescue Service
**SFS** – State Forest Service
**$SF_6$** – Sulphur hexafluoride
**$SO_2$** – Sulphur dioxide
**UN** – United Nations
**UNFCCC** – United Nations Framework Convention on Climate Change
**TERT** – Technical expert review team
**t-CER** – Temporary Certified Emission Reduction units

# EXECUTIVE SUMMARY

## *ES.1 Background Information on GHG inventories, climate change and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol*

### ES.1.1 Background information on climate change

Latvia takes part in the global climate change mitigation process and together with many other countries of the world signed the United Nations (UN) Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro the UN Conference on Environment and Development held in 1992. It entered into force on 21 March 1994. The Parliament of the Republic of Latvia (Saeima) ratified the UNFCCC on 23 February 1995. On May 30, 2002 the Parliament ratified the Kyoto Protocol.

Latvia is a member of European Union since May, 2004 and therefore has reporting obligations also under the Regulation (EU) No 525/2013 of the European Parliament and of the Council on a mechanism for monitoring and reporting GHG emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC (EU MMR). This regulation comprises reporting to fulfil the EU Effort Sharing Decision (406/2009/EC) and the EU LULUCF Decision (529/2013/EU). Commission Implementing Regulation (EU) No 749/2014 and the Commission Delegated Regulation (EU) No 666/2014 determine implementation of the Regulation (EU) No 525/2013.

Under these above mentioned agreements Latvia is required to provide annually information on anthropogenic greenhouse gas emissions by sources and removals by sinks of all greenhouse gases not controlled by Montreal Protocol from following sectors: Energy, Industrial Processes and Product Use, Agriculture, Land Use, Land Use Change and Forestry and Waste.

For the second commitment period of the Kyoto Protocol (agreement under Article 4 of the Kyoto Protocol) until 2020 European Union and its Member States, and Iceland has agreed to achieve jointly their quantified emission limitation and reduction commitment (QELRC) by 20% compared to the emissions in the base year or period during the 2013- 2020. The efforts of the reduction (reduction targets) are shared out as follows:

- 21% reduction compared to 2005 level for the emissions from sectors covered by the European Union Emission Trading Scheme (EU ETS); this goal is EU-wide and defines that all EU ETS operators jointly reduce the total GHG emissions;
- around 10% reduction compared to 2005 for other emitters (sectors and activities not included in the EU ETS which are regulated by Effort Sharing Decision[1] (EU ESD)). Member States have taken on binding annual targets for reducing their GHG emissions from the sectors not covered by the EU ETS, such as housing, agriculture, waste and transport (excluding aviation). The national targets, covering the period 2013-2020, are differentiated according to Member States relative wealth (measured by Gross Domestic Product (GDP) per capita. In accordance with EU ESD

[1] *http://ec.europa.eu/clima/policies/effort/index_en.htm*

(406/2009/EC) Latvia's national target is to limit emission growth to +17% above the 2005 level by 2020.

Allocated emission level of Latvia for the period 2013-2020 set out in the terms of the joint fulfilment for the second commitment period under the Kyoto Protocol is 76633439 tonnes carbon dioxide equivalent (Assigned amount). In addition to non – ETS emissions Latvia is responsible for the emissions/removals related to the Kyoto Protocol LULUCF activities according to decision 2/CMP.7.

### ES.1.2 Background information on greenhouse gas inventories

The annual greenhouse gas inventory contains information on the trends of national greenhouse gas emissions by sources and removals by sinks since 1990.

According to the Regulation No. 217 of Cabinet of Ministers (27.03.2012.) Ministry of Environmental Protection and Regional Development (MEPRD) is a single national entity with overall responsibility for the Latvia's GHG inventory. The main institutions involved in the compilation of the Latvia's GHG inventory are the MEPRD, Latvian Environment, Geology and Meteorology Centre (LEGMC), Latvian State Forest Research Institute "Silava", Latvia University of Agriculture (LUA), Institute of Physical Energetics (IPE). Description of the national greenhouse gas inventory system including the institutional arrangements is provided in Section 1.2.

The GHG inventory is prepared according to the UNFCCC Decision 24/CP.19[2] Annex I reporting guidelines "Guidelines for the preparation of national communications by Parties included in Annex I of the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories on annual inventories" (UNFCCC Annex I GHG inventory reporting guidelines) and tables of the common reporting format to implement the use of the 2006 IPCC Guidelines for National Greenhouse Gas inventories (2006 IPCC Guidelines), 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC Wetlands Supplement) and 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC KP Supplement).

For the preparation of the 2016 inventory submission CRF Reporter v5.14 software has been used. Due to severe problems with the CRF software in 2015 and 2016 minor inconsistencies and data display issues may still exist in the reporting tables.

### ES.1.2 Background information on supplementary information required under Article 7, paragraph 1 of the Kyoto Protocol

The required information is consistent with relevant decisions and guidelines under Article 7 paragraph 1 and includes information on Latvia's assigned amount for the second commitment period, corresponding emissions and removals (Chapter 12), changes in the national system (Chapter 13) and national registry (Chapter 14), information related to Article 3, paragraphs 3 and 4 (Chapter 11), and Article 3, paragraph 14 (Chapter 15). The summary of information on the accounting of Kyoto units is provided in Chapter 12.

[2] *http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf#page=2*

## *ES.2 Summary of National Emission and Removal-Related Trends*

### ES.2.1 GHG inventory

In 2014, Latvia's greenhouse gas emissions constituted 11353.38 kt $CO_2$ eq (without LULUCF) and 15573.52 kt $CO_2$ eq (with LULUCF). Latvia's total GHG emissions without LULUCF showed a decrease of 56.76% comparing to the base year, but GHG emissions with LULUCF have decreased by 12.68% compared to base year.

If compared to 2013 total GHG emissions excluding LULUCF have decreased by 0.5%, but including LULUCF GHG emissions have increased by 23.4% (Figure ES.1).

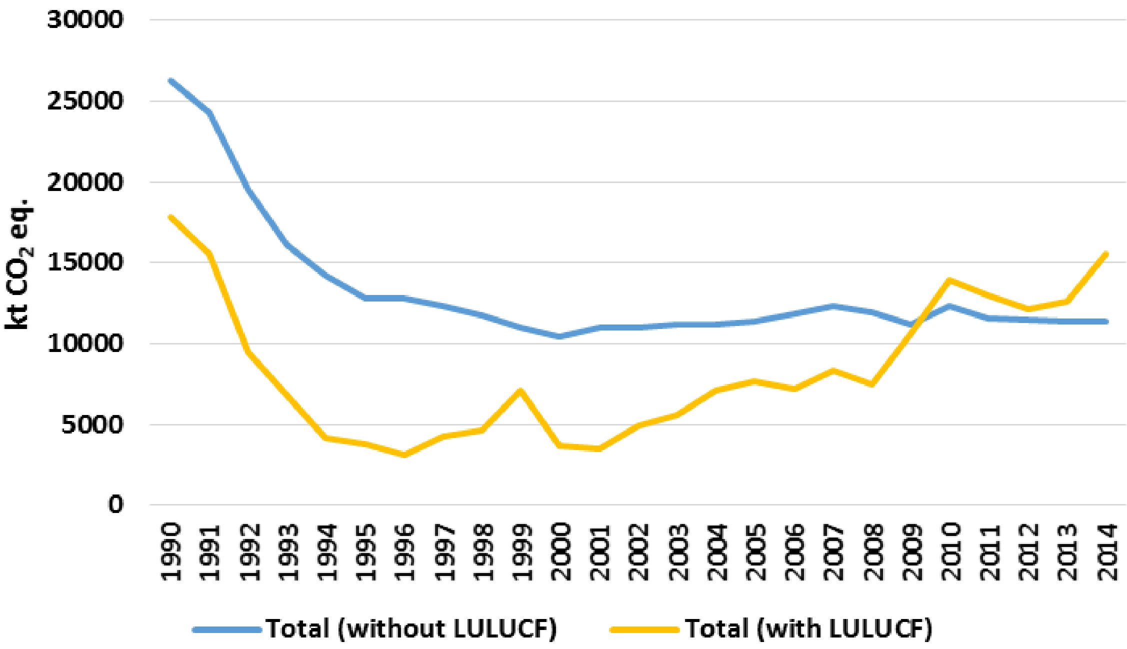


**Figure ES.1 Latvia`s total GHG emissions (with and without LULUCF) 1990–2014 (kt $CO_2$ eq.)**

Aggregated GHG emissions 1990 - 2014, kt $CO_2$ eq by gases are reflected in Table ES.1 a and Table ES.1 b and by sectors reflected in Table ES.2 a and Table ES.2 b.

**Table ES.1 a Aggregated GHG emissions by gases (1990 - 2002), kt $CO_2$ eq.**

| GREENHOUSE GAS EMISSIONS | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **kt $CO_2$ equivalent** | | | | | | | | | | | | | |
| $CO_2$ emissions including net $CO_2$ from LULUCF | 19696.76 | 17917.75 | 14185.15 | 11924.39 | 10364.81 | 9115.53 | 9189.79 | 8660.94 | 8286.62 | 7702.50 | 7069.73 | 7484.81 | 7513.66 |
| $CO_2$ emissions excluding net $CO_2$ from LULUCF | 10391.42 | 8356.27 | 3195.54 | 1792.22 | -586.35 | -825.79 | -1442.51 | -309.28 | 186.74 | 2891.01 | -570.20 | -927.66 | 540.21 |
| $CH_4$ emissions including $CH_4$ from LULUCF | 3671.26 | 3618.13 | 3127.74 | 2399.59 | 2221.66 | 2195.31 | 2149.66 | 2114.38 | 2020.45 | 1886.83 | 1922.68 | 2011.13 | 1988.24 |
| $CH_4$ emissions excluding $CH_4$ from LULUCF | 3978.78 | 3920.49 | 3513.28 | 2707.83 | 2528.59 | 2512.92 | 2470.30 | 2439.73 | 2347.79 | 2246.75 | 2268.63 | 2318.27 | 2323.97 |
| $N_2O$ emissions including $N_2O$ from LULUCF | 2888.42 | 2733.79 | 2211.11 | 1784.12 | 1623.45 | 1476.64 | 1497.21 | 1507.69 | 1465.25 | 1396.00 | 1420.33 | 1517.21 | 1478.85 |
| $N_2O$ emissions excluding $N_2O$ from LULUCF | 3464.60 | 3311.17 | 2800.02 | 2365.67 | 2206.13 | 2062.45 | 2085.22 | 2098.48 | 2058.25 | 1993.90 | 2018.53 | 2112.76 | 2079.87 |
| HFCs | NO,NA,NE | NO,NA,NE | NO,NA,NE | NO,NA,NE | NO,NA,NE | 11.50 | 12.59 | 12.73 | 15.33 | 17.07 | 20.46 | 23.92 | 27.20 |
| PFCs | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA |
| Unspecified mix of HFCs and PFCs | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA |
| $SF_6$ | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | 0.17 | 0.18 | 0.37 | 0.52 | 0.71 | 0.88 | 1.39 | 2.62 |
| $NF_3$ | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA |
| **Total (without LULUCF)** | 26256.43 | 24269.68 | 19524.00 | 16108.10 | 14209.92 | 12799.16 | 12849.42 | 12296.11 | 11788.17 | 11003.11 | 10434.07 | 11038.46 | 11010.57 |
| **Total (with LULUCF)** | 17834.80 | 15587.93 | 9508.84 | 6865.72 | 4148.37 | 3761.25 | 3125.77 | 4242.03 | 4608.63 | 7149.43 | 3738.30 | 3528.68 | 4973.87 |
| **Total (without LULUCF, with indirect)** | 26299.86 | 24310.73 | 19562.26 | 16144.28 | 14245.38 | 12833.33 | 12881.87 | 12326.59 | 11817.09 | 11031.09 | 10460.47 | 11064.39 | 11036.92 |
| **Total (with LULUCF, with indirect)** | 17878.23 | 15628.98 | 9547.09 | 6901.91 | 4183.83 | 3795.42 | 3158.22 | 4272.51 | 4637.55 | 7177.41 | 3764.70 | 3554.61 | 5000.22 |

**Table ES.1 b Aggregated GHG emissions by gases (2003 - 2014), kt $CO_2$ eq.**

| GREENHOUSE GAS EMISSIONS | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | Change from 1990 to latest reported year (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kt $CO_2$ equivalent | | | | | | | | | | | | |
| $CO_2$ emissions including net $CO_2$ from LULUCF | 7710.50 | 7721.00 | 7796.46 | 8293.58 | 8616.09 | 8188.85 | 7443.50 | 8528.14 | 7785.47 | 7500.68 | 7331.99 | 7139.01 | -63.76 |
| $CO_2$ emissions excluding net $CO_2$ from LULUCF | 1233.72 | 2733.73 | 3185.62 | 2643.19 | 3679.80 | 2874.11 | 5876.01 | 9149.89 | 8165.60 | 7139.68 | 7483.51 | 10272.49 | -1.14 |
| $CH_4$ emissions including $CH_4$ from LULUCF | 1894.33 | 1871.49 | 1929.45 | 1906.51 | 1967.58 | 1962.60 | 1944.00 | 1949.62 | 1897.77 | 1971.19 | 2010.24 | 2082.21 | -43.28 |
| $CH_4$ emissions excluding $CH_4$ from LULUCF | 2208.82 | 2179.76 | 2211.32 | 2231.04 | 2248.81 | 2242.75 | 2247.45 | 2263.16 | 2226.59 | 2318.06 | 2376.88 | 2471.09 | -37.89 |
| $N_2O$ emissions including $N_2O$ from LULUCF | 1532.56 | 1523.55 | 1587.19 | 1597.04 | 1653.07 | 1641.94 | 1670.71 | 1711.99 | 1726.28 | 1823.61 | 1859.45 | 1911.52 | -33.82 |
| $N_2O$ emissions excluding $N_2O$ from LULUCF | 2133.09 | 2125.38 | 2187.28 | 2206.16 | 2256.70 | 2247.21 | 2294.35 | 2351.49 | 2382.43 | 2496.89 | 2550.06 | 2609.30 | -24.69 |
| HFCs | 31.18 | 47.54 | 63.48 | 98.09 | 123.59 | 142.02 | 152.14 | 164.42 | 184.97 | 190.21 | 204.35 | 212.06 | |
| PFCs | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NA,NO | |
| Unspecified mix of HFCs and PFCs | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NA,NO | |
| $SF_6$ | 2.76 | 3.25 | 3.78 | 4.07 | 4.55 | 5.23 | 7.33 | 7.35 | 7.47 | 7.78 | 8.50 | 8.58 | |
| $NF_3$ | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NO,NA | NA,NO | |
| **Total (without LULUCF)** | 11171.32 | 11166.82 | 11380.36 | 11899.29 | 12364.87 | 11940.64 | 11217.68 | 12361.52 | 11601.95 | 11493.46 | 11414.54 | 11353.38 | -56.76 |
| **Total (with LULUCF)** | 5609.57 | 7089.66 | 7651.48 | 7182.55 | 8313.44 | 7511.32 | 10577.28 | 13936.31 | 12967.06 | 12152.61 | 12623.30 | 15573.52 | -12.68 |
| **Total (without LULUCF, with indirect)** | 11192.38 | 11187.13 | 11401.99 | 11915.74 | 12382.82 | 11957.86 | 11234.02 | 12377.17 | 11612.38 | 11505.76 | 11429.70 | 11373.59 | -56.75 |
| **Total (with LULUCF, with indirect)** | 5630.63 | 7109.98 | 7673.11 | 7199.00 | 8331.39 | 7528.54 | 10593.62 | 13951.96 | 12977.48 | 12164.92 | 12638.46 | 15593.73 | -12.78 |

**Table ES.2 a Aggregated GHG emissions by sectors (1990 - 2001), kt $CO_2$ eq.**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kt $CO_2$ equivalent | | | | | | | | | | | | |
| **1. Energy** | 19283.59 | 17767.42 | 14434.58 | 12339.12 | 10710.49 | 9447.74 | 9513.29 | 8943.56 | 8528.63 | 7893.77 | 7278.72 | 7703.47 |
| **2. Industrial processes and Product Use** | 707.49 | 610.71 | 322.83 | 169.86 | 217.84 | 237.25 | 249.20 | 266.26 | 273.35 | 307.50 | 260.31 | 283.27 |
| **4. Agriculture** | 5454.03 | 5046.68 | 3960.74 | 2870.04 | 2569.14 | 2402.49 | 2373.38 | 2360.20 | 2255.46 | 2063.64 | 2098.00 | 2221.44 |
| **5. Land use, land use change and forestry** | -8421.63 | -8681.75 | -10015.17 | -9242.38 | -10061.55 | -9037.92 | -9723.65 | -8054.08 | -7179.54 | -3853.68 | -6695.77 | -7509.78 |
| **6. Waste** | 811.33 | 844.87 | 805.86 | 729.08 | 712.44 | 711.68 | 713.55 | 726.09 | 730.73 | 738.19 | 797.04 | 830.28 |
| **7. Other** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Total emissions (including LULUCF)** | 17834.80 | 15587.93 | 9508.84 | 6865.72 | 4148.37 | 3761.25 | 3125.77 | 4242.03 | 4608.63 | 7149.43 | 3738.30 | 3528.68 |

**Table ES.2 b Aggregated GHG emissions by sectors (2002 - 2014), kt $CO_2$ eq.**

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | Change from 1990 to latest reported year (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kt $CO_2$ equivalent | | | | | | | | | | | | | | |
| **1. Energy** | 7707.29 | 7863.85 | 7892.21 | 8003.77 | 8433.73 | 8758.30 | 8305.10 | 7584.11 | 8379.65 | 7511.33 | 7195.26 | 7117.63 | 6952.97 | -63.94 |
| **2. Industrial processes and Product Use** | 298.08 | 315.17 | 350.66 | 347.38 | 404.92 | 432.84 | 447.99 | 441.11 | 711.12 | 823.16 | 892.51 | 828.38 | 837.00 | 18.31 |
| **4. Agriculture** | 2202.85 | 2255.76 | 2187.26 | 2270.81 | 2278.80 | 2374.42 | 2352.33 | 2385.02 | 2430.52 | 2456.41 | 2573.92 | 2639.74 | 2726.42 | -50.01 |
| **5. Land use, land use change and forestry** | -6036.70 | -5561.76 | -4077.16 | -3728.88 | -4716.73 | -4051.43 | -4429.32 | -640.40 | 1574.79 | 1365.10 | 659.16 | 1208.75 | 4220.14 | -150.11 |
| **6. Waste** | 802.34 | 736.55 | 736.68 | 758.40 | 781.84 | 799.31 | 835.22 | 807.43 | 840.22 | 811.05 | 831.77 | 828.80 | 836.99 | 3.16 |
| **7. Other** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | |
| **Total emissions (including LULUCF)** | 4973.87 | 5609.57 | 7089.66 | 7651.48 | 7182.55 | 8313.44 | 7511.32 | 10577.28 | 13936.31 | 12967.06 | 12152.61 | 12623.30 | 15573.52 | -12.68 |

### ES.2.2 KP-LULUCF activities

For the LULUCF activities under Article 3 paragraphs 3 and 4, of Kyoto Protocol Latvia has chosen accounting at the end of period[3]. Therefore the accounting quantity will be reported in the annual report commitment submitted for the last year of the commitment period (in 2022) and calculated over the entire commitment period.

Article 3.3 covers human induced afforestation (A), reforestation (R) and deforestation activities, which should be accounted mandatory. Under Article 3.4 Latvia has elected the activity Forest Management (FM) for the second commitment period. Latvia's FM reference level for the second commitment period is -16302 kt $CO_2$ equivalent a year, including harvested wood products, and -14255 kt $CO_2$ equivalent a year assuming instantaneous oxidation of harvested wood products according to the appendix to the annex to decision 2/CMP.7[4]. Latvia will make technical corrections for the forest management reference level according to the requirements of decision 2/CMP.7 and 2/CMP.8.

## *ES.3 Overview of Source and Sink Category Emission Estimates and Trends*

### ES.3.1 GHG inventory

The main sources of greenhouse gas emissions are divided into the following sectors (according to Decision 24/CP.19): Energy (CRF 1), Industrial processes and Product Use (CRF 2), Agriculture (CRF 3), Land use, Land use change and Forestry (LULUCF) (CRF 4) and Waste (CRF 5). GHG emissions by sectors are shown in the Figure ES.2.

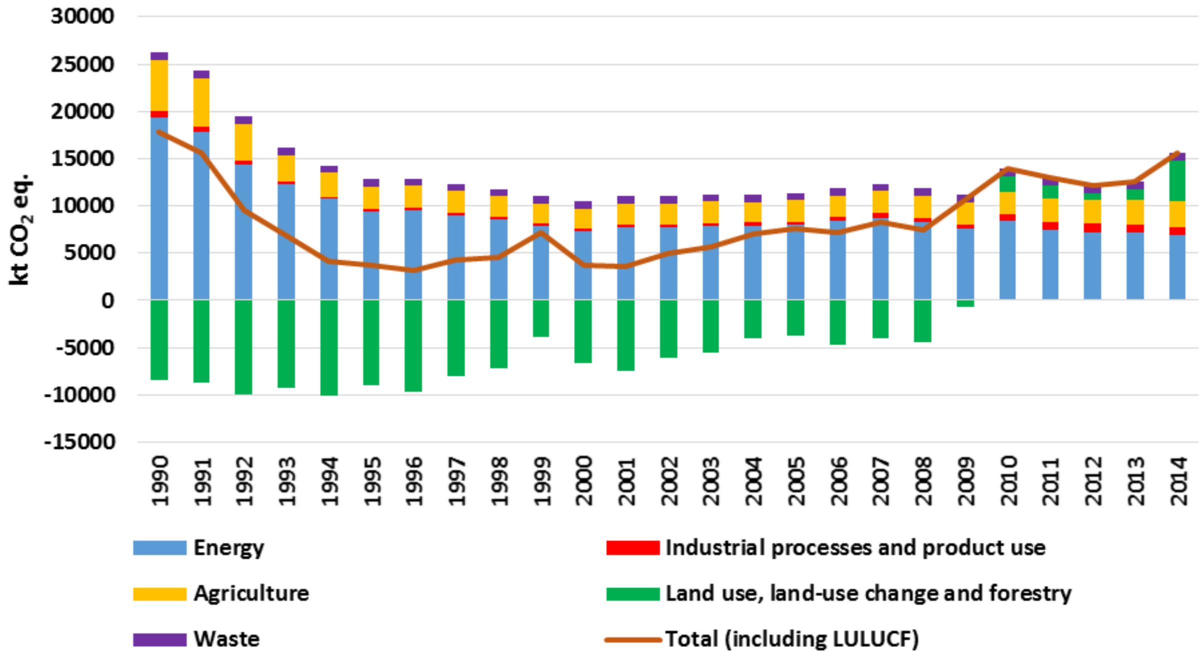


**Figure ES.2 Latvia`s GHG emissions and removals by sectors 1990-2014 (kt $CO_2$ eq.)**

[3] *Current version of CRF Reporter (v5.14) does not provide option to make the choice of accounting annually or at the end of the commitment period. "End of the period" option will be selected when this will be technically possible in CRF Reporter.*
[4] *http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf*

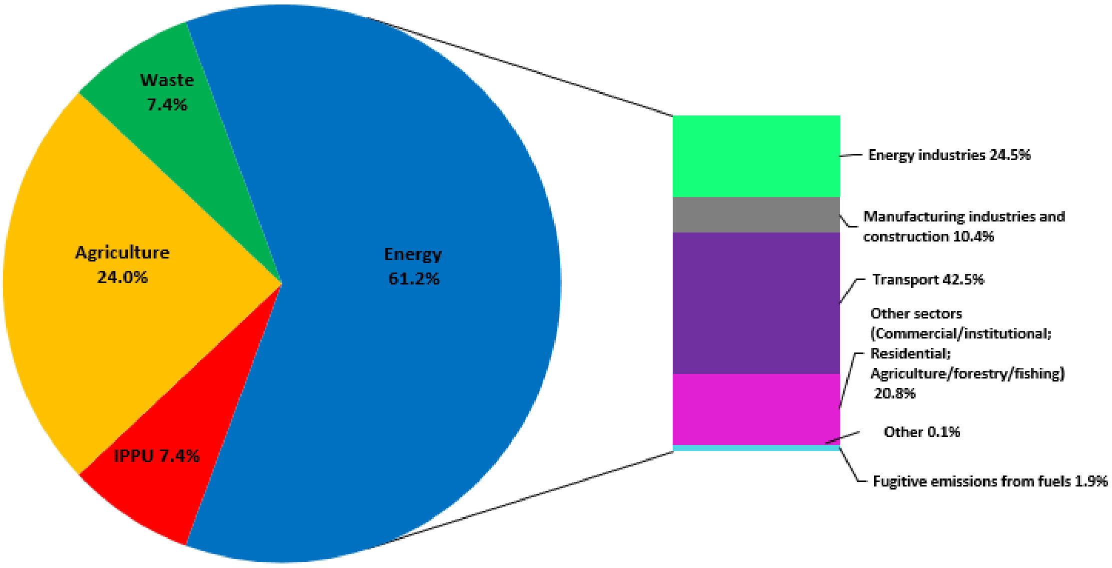


**Figure ES.3 The composition of Latvian greenhouse gas emissions in 2014 (excluding LULUCF)**

The **Energy sector** is the most significant source of GHG emissions with 61.2% share of the total emissions in the 2014. GHG emissions fluctuate in the latest years mainly due to the economic trend, the energy supply structure and climate conditions. Total emissions in Energy sector in 2014 decreased by 63.94% if compared to the base year. A large part of energy sector emissions comes from transport sector (42.5%). Emissions from transport increased by 4.3% compared to 2013 mainly due to GHG emission increase in road transport.

**Agriculture** is the second most significant source of GHG emissions, with approximately 24.0% of Latvia's total GHG emissions excluding LULUCF in 2014. Emissions from agriculture include $CH_4$, $N_2O$ emissions from enteric fermentation, manure management and agricultural soils and $CO_2$ emissions from liming and urea application. In 2014 GHG emissions have increased by 3.3% compared to 2013 due to increase of cattle, sheep and fur animal number, synthetic N fertilizer consumption, crop production and lime application to soils. The annual emissions have reduced approximately by 50% since 1990 due to decrease in agricultural production. In 2014, given in $CO_2$ eq, the $N_2O$ contributed 63.4%, $CH_4$ contributed 35.7% of total GHG emission from the agricultural sector, remaining 0.9% refer to $CO_2$ emissions from liming and urea application.

Emissions from the **Waste sector** contribute 7.4% of total GHG emissions excluding LULUCF in 2014. Emissions from Waste include $CH_4$ and $N_2O$ emissions from solid waste disposal, biological treatment of solid waste, incineration and open burning of waste as well as waste water treatment and discharge. Waste emissions have been fluctuating since 1990. In 2014, emissions were approximately 3.2% higher than in 1990, but compared to 2013 emissions increased by 1.0%. Trend could be explained with changes in economic situation in Latvia.

The emissions from **Industrial Processes and Product Use (IPPU)** (referred to as non-energy related ones), include $CO_2$, $CH_4$, $N_2O$ and F-gases. The category constitutes 7.4% of the total GHG emissions excluding LULUCF in 2014. Compared to 1990 emissions from IPPU have increased by 18.3%, but compared to 2013 emissions increased by 1.0%.

The largest decrease in IPPU emissions occurred between years 1991 and 1993, when industry was affected by a crisis. Emission fluctuations in product uses sectors are also linked with the economic situation of the country. In the latest years emissions increased significantly due to overall increase of activity in industrial production processes.

F-gases emissions from 2.F Product uses as substitutes for ozone depleting substances (ODS) constitute 1.9% from total GHG emissions excluding LULUCF in 2014. Emissions from HFC and $SF_6$ have grown significantly since 1995. Compared to 2013 F-gases emissions increased by 3.8% due to increase of activity data reported by F-gases importers and users.

In 2014 indirect $CO_2$ emissions from Solvent Use sector have decreased by 3.2%, compared to 2013. Solvent Use sector was the largest NMVOC emission source in Latvia and it covered 32.8% (14.65 kt) from the total Latvia's NMVOC emissions in 2014.

Net GHG emissions from **Land use, Land use change and forestry (LULUCF)** in 2014 were 4220.14 kt $CO_2$ eq compared to -8421.63 kt $CO_2$ eq in the base year. Change from base to latest reported year of emissions/removals from LULUCF constitutes -150%. This decrease of removals from LULUCF sector is related to increase of harvesting stock (more than double), increase of natural mortality due to ageing of forest stands and reduction of increment in ageing forests. The difference between previous and latest submission is due to recalculation of deforested area in 2009-2013 resulting in increase of deforested area and considerably higher GHG emissions due to land use change to cropland and settlements category. Besides, harvested wood products (HWP) has significant role in recalculations of the carbon stock changes in living biomass in LULUCF sector in 2012 and 2013. Due to changes in export and import data in FAO and Eurostat databases, recalculations of HWP lead to increase of emissions by 0.3 mill. tonnes $CO_2$.

### ES.3.2 KP-LULUCF activities

Information table on accounting for activities under Articles 3.3 and 3.4 of the Kyoto Protocol is shown in the Table ES.3.

**Table ES.3 Accounting for activities under Articles 3.3 and 3.4 of the Kyoto Protocol**

| Greenhouse gas source and sink activities | Net emissions/removals | | | | | | | | | Accounting parameters | Accounting quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Total | | |
| **A. Article 3.3 activities** | | | | | | | | | | | |
| **A.1. Afforestation and Reforestation** | -85.68 | -89.64 | | | | | | | -175.32 | | -175.32 |
| **Excluded emissions from natural disturbances** | NA | NA | | | | | | | NA | | NA |
| **Excluded subsequent removals from land subject to natural disturbances** | NA | NA | | | | | | | NA | | NA |
| **A.2. Deforestation** | 1383.41 | 1404.83 | | | | | | | 2788.23 | | 2788.23 |
| **B. Article 3.4 activities** | | | | | | | | | | | |
| **B.1. Forest management** | | | | | | | | | -3920.99 | | 7351.80 |
| **Net emissions/removals** | -3492.58 | -428.40 | | | | | | | -3920.99 | | |
| **Excluded emissions from natural** | NA | NA | | | | | | | NA | | NA |

| Greenhouse gas source and sink activities | Net emissions/removals | | | | | | | | | Accounting parameters | Accounting quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Total | | |
| disturbances | | | | | | | | | | | |
| Excluded subsequent removals from land subject to natural disturbances | NA | NA | | | | | | | NA | | NA |
| Any debits from newly established forest (CEF-ne) | NA | NA | | | | | | | NA | | NA |
| Forest management reference level (FMRL) | | | | | | | | | | -16302.00 | |
| Technical corrections to FMRL | | | | | | | | | | 9922.00 | |
| Forest management cap[5] | | | | | | | | | | 7351.80 | 7351.80 |
| B.2. Cropland management | NA | NA | | | | | | | NA | | NA |
| B.3. Grazing land management | NA | NA | | | | | | | NA | | NA |
| B.4. Revegetation | NA | NA | | | | | | | NA | | NA |
| B.5. Wetland drainage and rewetting | NA,NO | NA,NO | | | | | | | NA,NO | | NA,NO |

## *ES.4 Overview of Emission Estimates and Trends of Indirect GHG and $SO_2$*

Emissions from indirect GHGs are presented in Table ES.4.

**Table ES.4. Indirect GHG emissions 1990-2014 (kt)**

| | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|
| | kt | | | |
| **1990** | 92.95 | 389.29 | 91.04 | 99.98 |
| **1991** | 86.25 | 356.46 | 86.02 | 81.68 |
| **1992** | 70.76 | 374.24 | 79.56 | 69.79 |
| **1993** | 62.39 | 338.74 | 73.55 | 65.74 |
| **1994** | 56.20 | 322.05 | 70.05 | 66.71 |
| **1995** | 51.16 | 297.43 | 67.81 | 49.39 |
| **1996** | 50.94 | 302.89 | 66.96 | 55.67 |
| **1997** | 49.14 | 275.16 | 63.52 | 43.91 |
| **1998** | 45.47 | 257.79 | 60.55 | 39.84 |
| **1999** | 44.35 | 258.74 | 58.55 | 31.95 |
| **2000** | 43.52 | 243.58 | 57.32 | 17.56 |
| **2001** | 46.31 | 241.72 | 59.75 | 14.10 |
| **2002** | 45.18 | 243.32 | 58.15 | 12.77 |
| **2003** | 46.85 | 232.98 | 56.72 | 11.93 |
| **2004** | 46.04 | 224.44 | 56.04 | 10.11 |
| **2005** | 44.33 | 203.59 | 54.53 | 8.83 |
| **2006** | 45.27 | 219.56 | 53.14 | 8.52 |
| **2007** | 44.79 | 186.67 | 53.86 | 8.11 |

*[5] FM cap is calculated in accordance with paragraph 13 of the annex to decision 2/CMP.7, 3.5 per cent of the national total emissions excluding LULUCF in the base year times eight.*

| | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|
| | kt | | | |
| **2008** | 41.04 | 174.05 | 52.17 | 6.65 |
| **2009** | 38.58 | 185.85 | 50.39 | 6.42 |
| **2010** | 41.20 | 148.49 | 44.24 | 4.48 |
| **2011** | 35.29 | 152.01 | 43.65 | 4.27 |
| **2012** | 35.48 | 156.41 | 46.98 | 4.33 |
| **2013** | 35.21 | 142.41 | 44.12 | 3.83 |
| **2014** | 35.20 | 138.44 | 44.69 | 3.76 |

In the period from 1990 to 2014 indirect GHG emissions have decreased: $NO_x$ by 62%, CO by 64% and NMVOC by 51%. Starting from 2001, slight fluctuations in $NO_x$, NMVOC and CO emissions can be observed as a reason of increasing firewood consumption in Residential sector as well as fuel consumption in Transport sector in particular years. $SO_2$ emissions have decreased significantly from 1990 to 2014 by 96% because of fuel switch and approved legislation.

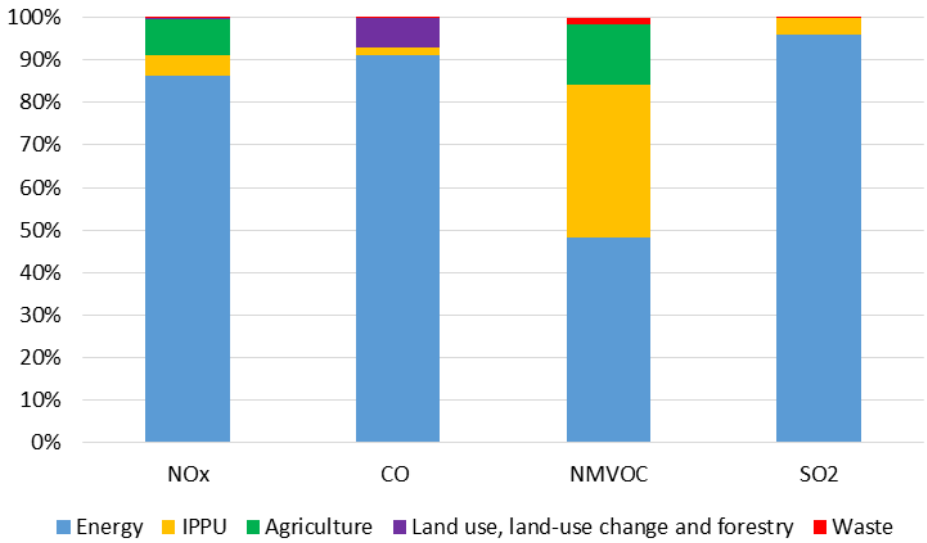


**Figure ES.4 Indirect GHG emission by sector in 2014 (% of total indirect GHG emissions in sector)**

In 2014, the most important sector producing indirect GHGs (including LULUCF) was Energy sector (including fugitive emissions). Fuel combustion in Energy sector causes the largest part of $NO_x$ emissions (86.2% from total $NO_x$ emissions in 2014), but IPPU and Agriculture sectors make 5.1% and 8.3%, accordingly. Very small part of $NO_x$ emissions is produced in LULUCF sector (0.5% from total NOx emissions). Almost all CO emissions (91.3%) appear in Energy sector, mainly from fuel combustion in Residential and Commercial/Institutional subsectors (70.8% from all emissions). A small part of CO emissions come from LULUCF sector (7.1%) and IPPU sector (1.6%). The major part of $SO_2$ emissions (95.9%) comes from Energy sector (fuel combustion), but the other sulphur dioxide emissions come from Industrial processes (Cement production and Iron and Steel production), and a negligible part of $SO_2$ comes also from Waste sector (Waste incineration). The largest amounts of NMVOC emissions are produced in Energy sector (48.3%; fuel combustion mainly in Residential sector)and 39.8% from total NMVOC emissions in 2014 are produced in IPPU sector (35.8%), mainly from solvent use. 14.1% of NMVOC emissions are produced in Agriculture sector, but the remaining 1.8% in Waste sector. In Agriculture sector, CO and $SO_2$ emissions, and in LULUCF sector, NMVOC and $SO_2$ emissions do not appear.

# PART I: ANNUAL INVENTORY SUBMISSION

# 1 INTRODUCTION

## *1.1 Background Information on Greenhouse Gas Inventories, Climate Change and supplementary information required under Article 7, Paragraph 1, of the Kyoto Protocol*

### 1.1.1 Background information on climate change

Latvia is a country by the Baltic Sea with total area of 64 573 km$^2$ and there are 2 001 468 (2014) inhabitants[6]. Baltic coastline is approximately 498 km. Since the beginning of the previous century the forest area in Latvia has almost doubled reaching 3 299.38 kha (51% from the total area of the country in 2014). Latvia lies in a temperate climate zone where active cyclone determines rapid changes in weather conditions (190-200 days per year). Annual mean precipitation is 600-700 mm. Main rocks in Latvia are clay, dolomite, sand, gravel, limestone and gypsum.

The analysis of long-term climatological data series in Latvia has shown that the climate has changed during last centuries. Air temperature has increased for the whole period of observations (from the 1795); however it has been more expressed during winter and spring and for the last decades. Increasing trends are evident in precipitation series for the cold period, while the decreasing trends were found for summer and autumn seasons. Ice and snow cover period in Latvia became shorter during last decades. River discharge regime has been subjected to major changes in relation to climate changes. Well expressed regular changes of high-water and low-water periods are evident. Seasonality indices have changed: increased values of growing degree days especially from the beginning of the 20$^{th}$ century, decreased number of frost days, reduced heating degree-days.

The climate change and climate variability have and will have a notable impact on inland and sea hydro ecosystems as well as changes in vegetation. The increasing growth of aquatic vegetation in recent years has been related to climatic factors – higher mean temperature and earlier spring. The absence and lowering of the ice cover during winter's causes the prolonged growing season. There is a significant temporal gradient in vegetation dynamic from light nutrient-poor and species-poor forests to more nutrient-rich, more diverse species and closed forests. This is evident that the future climate changes will have significant effect on natural and socio-economic systems in Latvia[7].

### 1.1.2 Background information on greenhouse gas inventories

The Parliament of the Republic of Latvia ratified the United Nations Framework Convention on February 23, 1995 and since March 23, 1995 Latvia is a Party to the Convention thus undertaking to implement series of international commitments. On May 30, 2002 the Parliament also ratified the Kyoto Protocol. Latvia is a member of EU since May 2004 and Latvia's climate change policy is based on Europe Union climate policy.

As a party of the UNFCCC, Kyoto Protocol and European Union Latvia is required to submit annual national GHG inventory covering emissions and removals of direct GHGs ($CO_2$, $CH_4$,

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[6] *http://data.csb.gov.lv/pxweb/lv/Sociala/Sociala__ikgad__iedz__iedzskaits/IS0020.px/table/tableViewLayout1/?rxid=cdcb978c-22b0-416a-aacc-aa650d3e2ce0*

[7] *Kļaviņš, M. Climate change in Latvia. University of Latvia.*

$N_2O$, HFC, PFC, $SF_6$ and $NF_3$) from the base year to the most recent inventory year. This report is the annual submission of the Latvia to the UNFCCC, Kyoto protocol and European Commission. It presents the GHG inventory, the process and the methods used for the compilation of the inventory for 1990 to 2014. The structure of NIR follows the UNFCCC Annex I GHG inventory reporting guidelines.
The legislation act – Regulation No. 217 of Cabinet of Ministers (27.03.2012.) determinates the institutions that are responsible for GHG inventory preparation. Ministry of Environmental Protection and Regional Development (MEPRD) Climate Change Department is responsible for the implementation and development of climate change mitigation and adaptation (and related) policies and measures. MEPRD is responsible for the actions (coordination, implementation and development) to meet the international and EU emission reduction targets. MEPRD also coordinates the monitoring and reporting of GHG emission data as well as is designated as the single national entity with overall responsibility for the Latvian GHG inventory.

### 1.1.3 Overview of inventory preparation and management, including for supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Latvia, as an Annex I Party that is also part of the Kyoto Protocol is required to report supplementary information in accordance with Article 7, paragraph 1, of the Kyoto Protocol. The required information is consistent with relevant decisions and guidelines under Article 7 paragraph 1.

## *1.2 Description of the institutional national inventory arrangements*

### 1.2.1 Overview of institutional, legal and procedural arrangements for compiling GHG inventory and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

The national inventory arrangements are described below. The description is prepared according to requirements for reporting on national inventory systems under the Kyoto Protocol, EU MMR and UNFCCC reporting guidelines.

Latvian national GHG inventory system is designed and operated according to the Kyoto Protocol to ensure the transparency, consistency, comparability, completeness and accuracy of inventory.

Inventory activities include planning, preparation and management.
The inventory phases are:

- collecting activity data;
- selecting methods and emission factors appropriately;
- estimating anthropogenic GHG emissions by sources and removals by sinks;
- implementing uncertainty assessment;
- implementing QA/QC activities.

A schematic model for the national system (NIS) according to the CoM Regulation No.217 (27.03.2012) is shown in Figure 1.1.

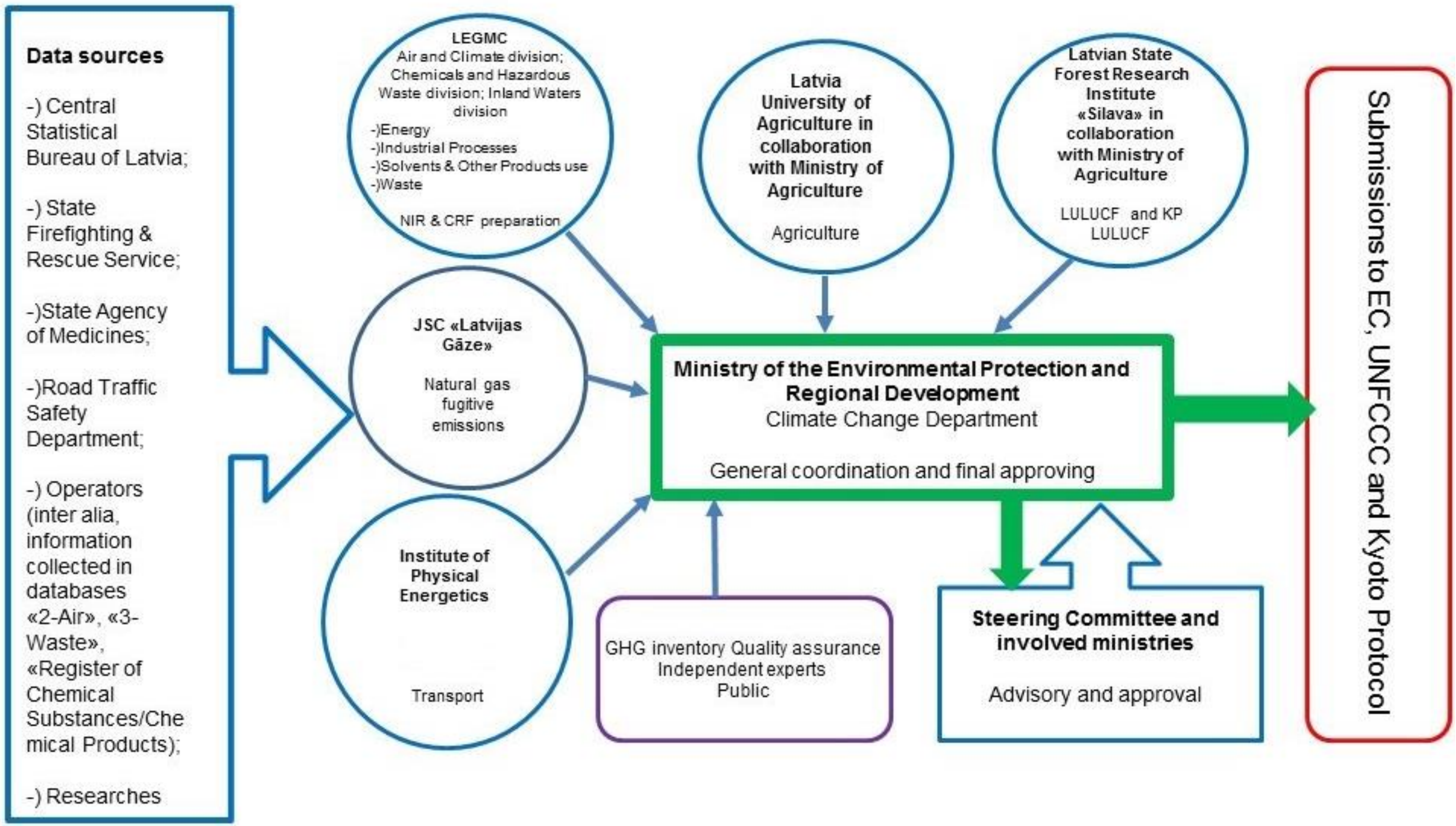


**Figure 1.1 The structure of Latvia`s National Inventory System**

The MEPRD Climate Change Department is responsible for:

- Preparation of legal basis for maintaining the National System;
- Informing the inventory compilers about requirements of the national system;
- Overall coordination of GHG inventory process;
- Final checking and approving of the GHG inventory before official submission to the EC and UNFCCC;
- Formal agreements with inventory experts and for third part experts that evaluate quality assurance process;
- Coordinating the work between the involved institutions, experts, European Commission and UNFCCC (including coordination of the UNFCCC inventory reviews);
- Timely submission of GHG inventory to the UNFCCC and European Commission;
- Keeping of archive of official submissions to UNFCCC and European Commission.

Latvian Environment, Geology and Meteorology Centre (LEGMC) is a governmental limited liability company and is responsible for:

- Collecting of activity data for Energy, Industrial Processes and Product Use and Waste sectors (activity data are mainly collected from other institutions and LEGMC (Air and Climate division, Chemicals and Hazardous Waste division, Inland Waters division) use them to calculate emissions);
- Preparation of the emission estimates for the Energy, Industrial Processes and Product Use and Waste sectors;
- Preparation of QC procedures for relevant categories and documentation and archiving of used materials for emission calculation;
- LEGMC Air and Climate Division compile the final NIR using information from all involved institutions as well as summarized emission data in CRF Reporter;
- Quality manager from LEGMC Air and Climate division perform the overall QC/QA procedures for all sectors according to the QA/QC plan;
- LEGMC is the National Emissions Trading Authority in Latvia and prepare relevant information for GHG inventory from registry – on emission reduction units, certified emission reductions, temporary certified emission reductions, long term certified emission reductions and assigned amount units for annual inventory submissions in accordance with guidelines for preparation of information under Article 7 of the Kyoto Protocol (SEF tables).

Calculations of removals and emissions for the LULUCF, KP-LULUCF sector were done by Latvian State Forest Research Institute "Silava" in collaboration with MoA. LSFRI "Silava" is responsible for collecting of activity data, preparation of the removals/emission estimates, preparation of QC procedures as well as documentation and archiving of used materials for calculation.

Institute of Physical Energetic (IPE) calculates emissions for Transport sector. IPE is responsible for collecting of activity data, preparation of the emission estimates, preparation of QC procedures as well as documentation and archiving of used materials for calculation.

Emission calculations from Agriculture sector were done by Latvia University of Agriculture in collaboration with MoA. Latvia University of Agriculture is responsible for collecting of necessary activity data cooperating with Central Statistical Bureau (CSB), preparation of the emission estimates, preparation of QC procedures as well as documentation and archiving of used materials for calculation.

The main data supplier for the Latvian GHG inventory is the CSB.

For ensuring the continuity of the functions of the national system, the delegation contracts are signed between the MEPRD and LEGMC, LSFRI "Silava", IPE and Latvia University of Agriculture.

Before final GHG inventory are submitted to European Commission and UNFCCC secretariat draft inventory submission to the EU 15 January is sent to the involved Latvia's ministries for comments and approving. Based on received comments inventory is corrected appropriate.

Several sectoral meetings were held before and during preparation of inventory to discuss and agree on the methodological issues, problems that have arisen and improvements that need to be implemented. There were discussions on the different problems that came up during the last inventory preparation to find solutions how to improve the overall system.

The following issues for solving different problems and to improve cooperation between inventory experts and inventory compilers are:

- Discussion on methodologies and possible changes in the future;
- Discussion on QA/QC plan, available resources and possible improvements;
- Discussion on data collection;
- Agreement on recalculations;
- Archiving system, updating and possible improvements;
- Exchange of relevant information;
- Reporting the conclusions from the meetings.

The detailed responsibilities of the institutions of activity data and main experts responsible for the sectoral inventories and the corresponding charters and annexes are summarized in the Table 1.1.

### 1.2.2 Overview of inventory planning, preparation and management, including for supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Inventory planning is one of the main stages in national GHG inventory management system and all responsible institutions are involved in this process, which consists of:

- establishing of national entity with overall responsibility for the national inventory;
- assigning responsibilities for inventory preparation and management;
- developing time schedule;
- making arrangements to collect data from statistical agencies, companies, industry associations, etc.;
- creating QA/QC plan;

- defining formal approval process within government;
- developing review processes;
- implementing continuous improvements.

The inventory preparation plan is a part of the Latvia's QA/QC plan and has to be followed by all institutions defined in CoM Regulation No. 217 (27.03.2012)[8]. The responsible institutions are reflected in the Table 1.1 and inventory preparation plan is presented in Table 1.2.

After the end of the annual reporting cycle in April, the institutions involved in inventory preparation start to plan the next annual inventory following received improvements and recommendations by ERT. Within the EU level the recommendations by a Technical Expert Review Team (TERT) are also taken into account. Planning includes the identification of improvements to be undertaken due to revised methodologies, updated activity data or emission factors and other relevant technical elements of inventory as well as addressing the issues and recommendations in the review of the previous inventory submission.

**Table 1.1 Institutions responsible for activity data and calculating emissions**

| CRF sectors | Data | Responsible institutions/ Responsible experts |
|---|---|---|
| Table 1.A(a) - Fuel Combustion Activities (Sectoral Approach) | Activity data | CSB Environment and Energy Statistics Section, Road Traffic Safety Department (RTSD) |
| | Calculations | LEGMC Air and Climate division (Ieva Sile, Asnate Skrebele), Institute of Physical Energetics (Gaidis Klāvs, Larisa Gračkova) |
| Table 1.A(b) – $CO_2$ from Fuel Combustion Activities – Reference Approach | Activity data | CSB Environment and Energy Statistics Section |
| | Calculations | LEGMC Air and Climate division (Ieva Sīle, Asnate Skrebele) |
| Table 1.A(d) – Feedstock's and Non-Energy Use of Fuels | Activity data | CSB Environment and Energy Statistics Section |
| | Calculations | LEGMC Air and Climate division (Ieva Sīle, Asnate Skrebele) |
| Table 1.B.2. – Fugitive Emissions from Oil and Natural Gas | Activity data | CSB Environment and Energy Statistics Section |
| | Calculations | LEGMC Air and Climate Division (Ieva Sīle, Asnate Skrebele), JSC "Latvijas Gāze" |
| Table 1.D – International Bunkers and Multilateral Operations | Activity data | CSB Environment and Energy Statistics Section |
| | Calculations | Institute of Physical Energetics ( Gaidis Klāvs, Larisa Gračkova) |
| Table 2(I).A-E,G-H – Industrial Processes and Product Use | Activity data | CSB Population Statistics Section<br>State Agency of Medicines;<br>Research of experts;<br>LEGMC "2-AIR" and "Chemical" databases CSB Industrial Statistics Section<br>EU Emission Trading Scheme operators |
| | Calculations | LEGMC Chemicals and Hazardous Waste Division (Liga Rubene), LEGMC Air and |

[8] *http://likumi.lv/doc.php?id=246033.*

| CRF sectors | Data | Responsible institutions/ Responsible experts |
|---|---|---|
| | | Climate division/EU Emission Trading Scheme operators (Aiva Puļķe) |
| Table 2(II) F – Industrial Processes - HFCs, PFCs and $SF_6$ | Activity data | CSB Population Statistics Section, Environment and Energy Statistics Section<br>"Latvenergo" AS;<br>State Agency of Medicines;<br>Annual reports by operators using F-gases (reported to LEGMC)<br>Data from Chemicals Register (maintained by LEGMC) |
| | Calculations | LEGMC Air and Climate division (Vita Ratniece) |
| Table 3.A – Agriculture, Enteric Fermentation | Activity data | CSB Agricultural Statistics Section |
| | Calculations | Latvia University of Agriculture (Laima Bērziņa, Renāte Ondzule) |
| Table 3.B.1 - Agriculture, $CH_4$ Emissions from Manure Management | Activity data | CSB Agricultural Statistics Section |
| | Calculations | Latvia University of Agriculture (Laima Bērziņa, Renāte Ondzule) |
| Table 3.B.2 - Agriculture, $N_2O$ un NMVOC Emissions from Manure Management | Activity data | CSB Agricultural Statistics Section |
| | Calculations | Latvia University of Agriculture(Laima Bērziņa, Renāte Ondzule) |
| Table 3.D - Agriculture, Agricultural Soils | Activity data | LEGMC database "2-Water", Latvian State Forest Research Institute "Silava" |
| | Calculations | Latvia University of Agriculture (Laima Bērziņa, Renāte Ondzule) |
| Table 3 G Liming | Activity data | CSB |
| | Calculations | Latvia University of Agriculture (Laima Bērziņa, Renāte Ondzule) |
| Table 3 H Urea application | Activity data | CSB |
| | Calculations | Latvia University of Agriculture(Laima Bērziņa, Renāte Ondzule) |
| Table 4. A. Forest Land<br>Table 4. B. Cropland<br>Table 4. C. Grassland<br>Table 4. D. Wetlands<br>Table 4. E. Settlements<br>Table 4. F. Other Land | Activity data | National Forest monitoring program (NFI) |
| | Calculations | Latvian State Forest Research Institute "Silava" collaborated with Ministry of Agriculture (Andis Lazdiņš, Arta Bārdule, Aldis Butlers, Ainārs Lupiķis) |
| Table 4. B. Cropland – 4.B.1 Cropland remaining Cropland | Activity data – Area of organic soil | NFI, National studies and expert judgement |
| | Calculations – Net carbon stock change in organic soils | Latvian State Forest Research Institute "Silava" |
| Table 4. C. Grassland – 4.C.1 Grassland remaining Grassland | Activity data - Area of organic soil | National studies and expert judgment |
| | Calculations – Net carbon stock change in organic soils | National studies and expert judgment, Latvian State Forest Research Institute "Silava" |
| Table 4. (V) Biomass Burning | Activity data | State Fire and Rescue Service of Latvia, State forest service of Latvia |
| | Calculations | Latvian State Forest Research Institute "Silava" |

| CRF sectors | Data | Responsible institutions/ Responsible experts |
|---|---|---|
| KP LULUCF<br>NIR-1<br>NIR-2<br>NIR-2.1<br>NIR-3<br>4(KP) | Activity data | State Fire and Rescue Service of Latvia, State forest service of Latvia<br>National Forest monitoring program (NFI)<br>National studies and expert judgement |
| | Calculations | Latvian State Forest Research Institute "Silava" (Andis Lazdiņš, Arta Bārdule, Aldis Butlers, Ainārs Lupiķis) |
| Table 5 A - Waste, Solid Waste Disposal on Land | Activity data | LEGMC "3-Waste" database, Methane recovery installations |
| | Calculations | LEGMC Chemicals and Hazardous Waste Division (Intars Cakars) |
| Table 5 B – Biological Treatment and Solid Waste | Activity data | CSB, LEGMC Chemicals and Hazardous Waste Division |
| | Calculations | CSB, LEGMC Chemicals and Hazardous Waste Division (Intars Cakars) |
| Table 5.B.1 – Composting | Activity data | LEGMC Chemicals and Hazardous Waste Division |
| | Calculations | LEGMC Chemicals and Hazardous Waste Division (Intars Cakars) |
| Table 5 C – Incineration and open Burning of Waste | Activity data | LEGMC database "3-Waste" |
| | Calculations | LEGMC Chemicals and Hazardous Waste Division (Intars Cakars) |
| 5.D Wastewater Treatment and Discharge | Activity Data | LEGMC "2-Water" database, CSB statistics on national population and production rates of certain industries |
| | Calculations | LEGMC Inland Waters Division (Lauris Siņics) |

Inventory management system includes 3 main stages – inventory planning, preparation and management.

The inventory preparation stage consists of:

- Identification of key categories, which have a significant influence on a country's total inventory in terms of level or trend in emissions;
- Selection of methods, emission factors and all necessary relevant information for estimating anthropogenic GHG emissions by sources and removals by sinks;
- Collection of activity data;
- Managing recalculations from previous submissions taking into account updates of activity data by CSB, recommendations by ERT, TERT and suggestions from the third-part experts etc.
- NIR compilation;
- QA/QC plan implementation (include basic checks on entire inventory (Tier 1) and more in-depth investigations into key sources (Tier 2);
- Documentation.

The inventory management stage consists of:

- Implementation of inventory review processes (e.g., expert review, public review);
- Obtaining formal approval of final results and reporting within government;
- Submission reporting to UNFCCC;
- Making inventory information available to stakeholders and respond to information requests;
- Archiving all documentation and results (The special centralised folder is created where experts can upload/download and store all files and information related to inventory preparation);
- Continuous improvement feedback.

Latvia prepares a NIR and Common Reporting Format (CRF) tables annually according to requirements of the UNFCCC, the Kyoto Protocol and the EU MMR.

**Table 1.2 Inventory preparation plan**

| Element | Activity | Responsible performers | Procedures | Due date | |
|---|---|---|---|---|---|
| To reconsider the changes needed for the inventory, taking into account comments and recommendations made by the review team (ERT) | All institutions established by Regulation of Cabinet of Ministers No.217 (Part II „National Inventory System", Paragraph 3) | | All institutions involved in inventory preparation process to reconsider the changes needed for the inventory, taking into account comments and recommendations made by the review team (ERT) and send to national inventory compiler for summarizing. | Middle of May | |
| Annual meeting | All institutions established by Regulation of Cabinet of Ministers No.217 (Part II „National Inventory System", Paragraph 3) | | Participation of all institutions involved in inventory preparation and approval process. Discussions on previous submissions' review results and planned submission including necessary improvements, changes, recalculations, problems etc. | Till 30th June | |
| Activity data and description | Submission to LEGMC | EU Emission Trading Scheme (EU ETS) operators | EU ETS operators send to LEGMC activity data, $CO_2$ emission factors, $CO_2$ emissions and descriptions as verified GHG report for enterprises involved in EU ETS annually for previous year. | till 30th March | |
| | | | LEGMC uses EU ETS data in GHG inventory for emission estimates in Energy and Industrial Processes sectors. | | Starting from September |
| | | Operators | LEGMC (Air and Climate division, Chemicals and Hazardous Waste division, Inland Waters Division) collects information for emission calculation in following databases:<br>• "2-AIR" database; | till 15th June | |

| Element | Activity | Responsible performers | Procedures | Due date | |
|---|---|---|---|---|---|
| | | | • "3-Waste";<br>• "2-Water" databases;<br>• Chemical Register.<br>• Cement producer and Iron & Steel plant send additional information for detailed $CO_2$ emission estimation according to national legislation. | till 1st October | |
| | | | LEGMC uses data from databases for emission estimates in Energy (CRF1), IPPU (CRF2), Waste (CRF5) sectors. | | Starting from September |
| | | JSC "Latvijas Gāze" | The only natural-gas transmission, storage, distribution, and sales operator in Latvia sends the total fugitive emissions for previous year and short information of emission fluctuation according to national legislation. | till 1st October | |
| | | | LEGMC uses data from JSC "Latvijas Gāze for emission estimates in Energy (CRF1) sector. | | Starting from October |
| | | Ministry of Health collaborating with State Agency of Medicines (SAM) | SAM sends to LEGMC activity data – data of imported metered dose inhalers containing GHG (F gases subsector) and amount of used $N_2O$ for Anaesthesia (Solvent and other product use sector). | till 1st October | |
| | | | LEGMC uses data from SAM for emission estimates in IPPU sector. | | Starting from October |
| Activity data and description | Submission to LEGMC, Latvia University of | Statistical Bureau of | CSB send activity data regarding Energy, Agriculture, Industrial Processes and Product | till 1st October | |

| Element | Activity | Responsible performers | Procedures | Due date | |
|---|---|---|---|---|---|
| | Agriculture | Latvia (CSB) | Use and Waste sectors according to CoM Regulation No. 217.<br>Many of received and used activity data is available in CSB statistical databases: http://www.csb.gov.lv/dati/statistikas-datubazes-28270.html | | |
| | | | LEGMC, Latvia University of Agriculture use received data for Energy, Agriculture, Industrial Processes and Product Use and Waste sectors emission calculation | | Starting from October |
| | Submission to MEPRD/ LSFRI "Silava" | State Firefighting & Rescue Service (SFRS) | SFRS send to MEPRD activity data - area of last year`s grass burning (ha). | till 1st October | |
| | | | LSFRI "Silava" uses received data for emission calculation from biomass burning (CRF 4 (V)). | | Starting from October |
| Emissions/$CO_2$ removals | Data entry in the CRF Reporter according to CRF Reporter User Manual | LEGMC, Latvia University of Agriculture, IPE, LSFRI "Silava" | Data entry in the CRF Reporter by responsible sectoral experts. | till 15 December | |
| Emissions/ $CO_2$ removals descriptions | Preparation of NIR chapters | LEGMC, Latvia University of Agriculture, IPE, LSFRI "Silava" | LSFRI "Silava"/ Latvia University of Agriculture (in coloboration with MoA), LEGMC, IPE and MEPRD prepare relevant chapters of NIR | till 15 December | |
| CRF Reporter | Data check by sectoral experts | LEGMC, Latvia University of Agriculture, | Sectoral experts check the data in the CRF Reporter for consistency and quality assurance (e.g. to check whether the sum of | till 15 December | |

| Element | Activity | Responsible performers | Procedures | Due date | |
|---|---|---|---|---|---|
| | | IPE, LSFRI "Silava” | the following adds up to 100%, to check the year to year changes between values reported etc.).<br>LEGMC (Quality manager) checks completeness, consistency and quality assurance. | till 30 December | |
| Data in CRF, Draft NIR according to Regulation (EU) No 525/2013 and Commission Implementing Regulation 749/2014 | CRF, NIR, Annexes | MEPRD - Climate Change Department | After corrections in CRF tables, NIR \(if necessary) MEPRD uploaded CRF tables, XML, draft NIR, relevant Annexes to the EIONET CDR. | 15th January | |
| Quality control checks:<br>Draft NIR | QA | MEPRD - Climate Change Department | According to the CoM Regulation No. 217, MEPRD send to involved institutions Draft NIR for comments and approving.<br>NIR was uploaded in the LEGMC home page for review by public. | till 16th January | |
| | | Expert<br>Public | | | |
| | | All institutions involved in GHG emissions and removals preparation | Expert meetings to improve inventory, quality control activities etc. | January-February | |
| | | Involved institutions | Involved institutions send to MEPRD comments about NIR 1st draft and approval. | | 8th February |
| | | | | | |

| Element | Activity | Responsible performers | Procedures | Due date |
|---|---|---|---|---|
| | QC | All institutions involved in the GHG inventory preparation process | Answers to the compiled questions by EU review team, which based on 15/1 submissions (https://emrt.eea.europa.eu/).<br>MEPRD approves provided answers from experts.<br>Verification of national data in EC inventory and updates if necessary and response to EC.<br>This process includes collaboration with involved institutions for preparing of response to EC. | 28st February to 15th March |
| CRF data,<br>NIR according to Regulation (EU) No 525/2013 and Commission Implementing Regulation 749/2014 | CRF, NIR, Annexes | MEPRD - Climate Change Department | MEPRD uploaded CRF tables, XML and NIR to the EIONET CDR. | 15th March |
| NIR and emission data in CRF to UNFCCC | Inventory submission (CRF, NIR) | MEPRD - Climate Change Department | MEPRD uploaded approved GHG inventory to the UNFCCC portal. | 15th April |

### 1.2.3 Quality assurance, quality control and verification plan

QA/QC procedures are an important component in the development of greenhouse gas emission inventory preparation. The basic aim of the QA/QC process is to ensure the quality of the inventory and to contribute to the improvement of the inventory. Improving the submission during QA/QC process, the main findings and conclusions concerning the inventory quality and improvements needs to be considered and communicated into Latvia`s GHG inventory system for making decisions concerning the annual inventory process and next inventory preparation.

The outcomes of the QA/QC process results in a reassessment of inventory or source category uncertainty estimates. For example, if data quality is found to be lower than previously thought and this situation cannot be rectified in the timeframe of the current inventory, the uncertainty estimates are re-evaluated. Increased effort on QC results in improved emissions estimates and reduced uncertainties.

According to CoM Regulation No. 217 (27.03.2012.) all institutions involved in inventory process are responsible for implementing QC procedures.

Mainly Tier 1 general inventory QC procedures outlined in Table 6.1 of 2006 IPCC Guidelines are used.

The legislation act determines:

- the quality objectives for GHG inventory;
- tasks and responsibilities of involved institutions;
- QA/QC time schedule;
- QA/QC plan that has been prepared to improve transparency, comparability, and completeness of GHG inventory. In the QA/QC plan quality control procedures to be used before and during the compilation of GHG inventory are described;
- check-lists and procedure descriptions for experts and independent experts for quality assurance of GHG inventory;
- background for inventory improvement plan preparation activities.

Figure 1.2 shows the annual inventory process how the inventory is produced within the national system.

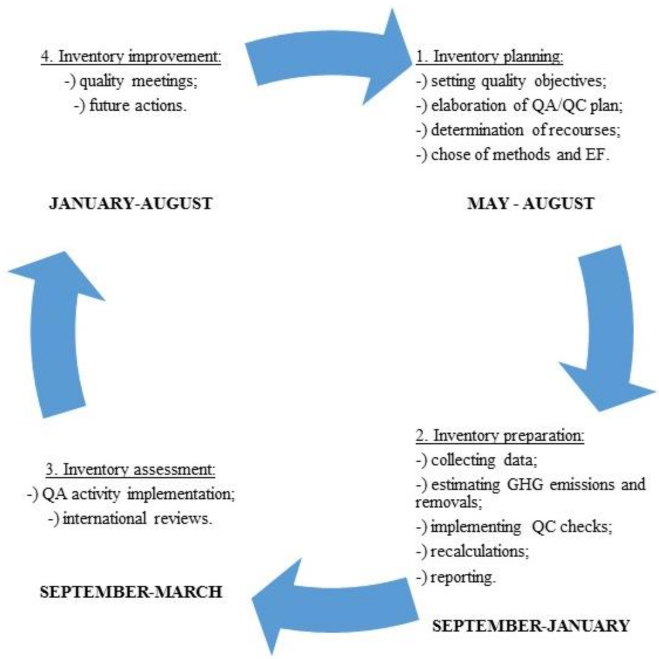


**Figure 1.2 Inventory Process**

The result of quality depends on four main stages – planning, preparation, evaluation and improvements and is ensured by inventory experts during compilation and reporting of inventory.

The inventory planning stage includes the setting of quality objectives and elaboration of the QA/QC plan for the coming inventory preparation, compilation and reporting work. The main objective of Latvia's GHG inventory system is to produce high quality GHG inventories.

The quality requirements set for the annual inventories – transparency, consistency, comparability, completeness, accuracy, improvements and timelines. To ensure these inventory principles the following QA/QC activities of the inventory is done (Figure 1.3).


**Figure 1.3 QA/QC activities of the inventory**

The setting of quality objectives is based on the inventory principles taking into account the available resources.

The quality objectives for the 2016 inventory were the following:

- Allocate sufficient resources for the implementation of the QA/QC plan especially with regard to the QC activities performed by the inventory compilers preparing the NIR and CRF tables;
- Allocate sufficient time and human resources to the final stages of the inventory compilation process in which cross-sectoral work such as the key category analysis occurs, and enhance the QC procedures so that errors are avoided in future annual submissions;

In order to ensure improvements:

- All improvements included in the previous NIR are carried out or ongoing;
- Feedback on reviews is systematic;
- Inventory QC procedures meet requirements.

In order to ensure transparency:

- transparent information is included in the NIR and CRF (including information regarding the used methodology, activity data and emissions in tables);
- notation keys are used according to the IPCC guidelines;
- recommendations of inventory reviews regarding transparency are taken into account as far as possible;
- documentation regarding quality control check is indicated;
- information regarding the changes since the last inventory in relation to transparency is provided in the NIR under relevant subchapters.

In order to ensure consistency:

- recommendations received during inventory reviews regarding consistency is taken into account after evaluation as far as possible;
- information regarding consistency and recalculations is provided in the NIR;
- an explanation for a decline or increase in emissions of time series is provided.

In order to ensure comparability:

- methodologies and formats used in the inventory meet comparability requirements;
- emissions and $CO_2$ removal is localized and distributed according to the IPCC.

In order to ensure completeness:

- emissions from all potential sources and gases is calculated;
- recommendations of review – international experts – regarding improvements is taken into account as far as possible;
- information regarding completeness is provided in the NIR;
- all reasons for recalculations and reasons why a designation NE (not evaluated) and IE (included elsewhere) is used instead of data is indicated;

In order to ensure accuracy:

- Tier 2 or a higher method is used for the main sources as far as possible;
- uncertainties are calculated and information is provided in the NIR;

In order to ensure timeliness:

- inventory reports reach their recipient (EU/UNFCCC) within the set time.

#### 1.2.3.1 Quality Control procedures

The general and category-specific QC procedures are performed by sectoral experts during inventory calculation and compilation according to the QA/QC and verification plan.

MEPRD as national entity is responsible for overall QC procedures and quality assurance of national system, including UNFCCC and EU reviews.

For submission 2016, QC activities were carried out at the various stages of the inventory compilation process - processing, handling, documenting, cross checking, and recalculations. These activities are implemented by sectoral experts and quality manager in LEGMC who is responsible for QC procedures before inventory submission for overall QC procedures and final approving in MEPRD.

The centralized archiving system (common FTP folder) is created where experts have to upload and download all necessary information for inventory preparation, inter alia spreadsheets which need to be filled for quality control and quality assurance. Instruction for experts how to prepare NIR to ensure comparability of NIR and CFR is prepared and available to experts.

QC system includes various activities set to ensure transparent data flow through all inventory process:

- Assumptions and criteria for the selection of activity data and emission factors are documented;
- Transcription errors in data input and references;
- Correctness of calculations of emissions;
- Correctness of emission parameters, units, conversion factors;
- Integrity of database files;
- Consistency in data between source categories.

The QC procedures comply with the 2006 IPCC Guidelines. General inventory QC checks include routine checks of the integrity, correctness and completeness of data, identification of errors and deficiencies and documentation and archiving of inventory data and quality control actions.

For Submission 2016:

-) The sectoral experts entered data in CRF Reporter software either manually or by importing MS Excel spreadsheets. Sectoral experts prepared quality control procedures according to 2006 IPCC Guidelines. All findings were documented by using check-lists and introduced in GHG inventory. All corrections are archived;

-) The sectoral experts prepared relevant NIR chapters and sent to LEGMC. Sectoral experts before sending chapter of NIR have checked if all information is consistent with information filled in the CRF Reporter. It is checked if recalculations and methodological changes are explained in NIR and CRF Reporter. Final NIR is compiled by LEGMC according to UNFCCC reporting guidelines;

-) Emission consistency with other EU MMR requirements are performed according to European Commission Implementing Regulation (EU) No 749/2014 (MMR IR). GHG emission data are checked with the data used to prepare inventories of air pollutants under EU

Directive 2001/81/EC, the actual or estimated allocation of the verified emissions reported by installations and operators under Directive 2003/87/EC, and the energy data reported pursuant to Article 4 of, and Annex B to, Regulation (EC) No 1099/2008.

-) LEGMC quality manager and MEPRD performed cross-checking for all sectors to verify that no mistakes occurred during input/import process. CRF completeness and consistency checks were carried out. During QA/QC procedures it was observed that there are still internal technical problems in CRF Reporter under Energy, IPPU, Agriculture and KP-LULUCF sectors;

-) Quality meetings between sectoral experts were held in order to discuss problems and possible improvements in GHG inventory as well as to ensure consistency between activity data used by experts in emission estimation for different sectors;

-) Detailed QA/QC procedures were done by institutions involved in the GHG inventory preparation (MoA, MEPRD, CSB). Meetings between sectoral experts and involved institutions were held according to comments received and improvements needed in NIR;

-) Experience exchange events with Norway GHG inventory experts were held within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy" in purpose to elaborate QA/QC procedures in sectors, improve uncertainty evaluation and improve overall quality of GHG inventory. Useful experience from Lithuanian experts regarding expert judgment documentation as well as uncertainty evaluation was also gained within previous mentioned project;

Main activity data provider for Latvia's GHG inventory – CSB – has established Quality Guidelines[9] that is an informative document describing the CSB and the main aspects of its activity: stages, methods and organizational principles of producing the national statistics, policy of data protection and dissemination. The purpose of the Guidelines is to ensure higher quality to a maximum extent from both ethical and professional aspect, national statistics similarly to the Community statistics must follow the principles of impartiality, reliability, relevance, cost-effectiveness, statistical confidentiality and transparency.

As a general rule the statistics are revised according to a fixed, coherent and published plan, called a revision cycle. This plan determines when the individual statistics are revised, and the periods that are subject to revision:

- CSB Revision Policy is available in the CSB website;
- Database of Macroeconomic statistics data revision analysis established.

Detailed source specific QC descriptions are included under each sub sector relevant chapter.

Quality control of EU Member States submissions` are performed in web-based tool hosted by the European Environmental Agency (EEA) to facilitate quality checks and reviews of national emission inventories reported by EU Member States under the EU MMR. From 2015 onwards the tool is used in the annual review process under the EU ESD. In 2015 voluntary review under EU ESD was carried out. Findings on errors and deficiencies are taking into account before Latvia submits final annual inventory to the UNFCCC.

[9] *Central Statistical Bureau Quality Guidelines (http://www.csb.gov.lv/en/dokumenti/quality-guidelines-30868.html).*

#### 1.2.3.2 Quality Assurance procedures

Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. According to Regulation No. 217 MEPRD is responsible for ensuring QA procedures for GHG inventory.

The QA reviews are performed after the implementation of QC procedures to the finalised inventory. The inventory QA system comprises reviews to assess the quality of the inventory.

A basic review of the draft GHG emission and removal estimates and the draft report takes place before the final submissions to the EU and UNFCCC (January to March) by the involved institutions on GHG inventory preparation process.

The draft of National inventory report (NIR), which was submitted to EU on 15$^{th}$ of January, was sent to CSB, MoE, MoA and MoT for checking and approving.

Improvements for GHG inventory are compiled based on the findings of the UNFCCC, EC, internal reviews and recommendations from third part experts (periodically all sectors are revised by third part experts. In previous submission LULUCF, LULUCF KP sectors were checked by international third part reviewer. Results are implemented in this report (Chapter 6 and Chapter 11)).

#### 1.2.3.3 Documentation and Archiving

As part of general QC procedures, it is good practice to document and archive all information that is used for emission estimates. Documentation has a significant role in the inventory quality management.

All institutions involved in GHG inventory preparation process are responsible for archiving the collected data and estimated emissions.

<u>Documentation system in CSB:</u>

- Survey and calculations documentation system;
- Quality indicators documentation system;
- Thesaurus;
- 2 sub-systems – internal & external.

CSB a Document Storage System (ADS):

- In 2008, ADS was developed in the CSB;
- Starting with 2009, each year all fundamental processes performed for each statistical survey as well as for calculations have to be described in detail;
- All quality indicators have to be described;
- ADS provides also a technical possibility to attach a number of supporting documents;
- ADS is made accessible for external users on the CSB website.

Revisions of data are defined as any changes to statistics that have already been published.

CSB uses integrated statistical data management system (ISDMS) for data processing. It is a metadata driven system based on metadata and standardisation of data processing, which in essence does not require individual programming. This system is used for processing surveys of business (mainly) and social statistics. Data collected by means of questionnaires which are not included in the ISDMS are processed by the CSB using other especially developed data processing applications. Detailed information is given in the Annex 5.

The expert organizations have archives located in their own facilities. Experts keep all information (all disaggregated emission factors, activity data, and documentation about how these factors and data have been generated and aggregated for the preparation of the inventory) on the hard disks of the individual expert's desktops.

Every annual inventory (CRF tables, XML, SQL Databases, NIR and Registry information) is archived.

Latvia has a centralized archiving system - all information (including corresponding letters, internal documentation on QA/QC procedures, external and internal reviews, documentation on annual key sources and key source identification, planned inventory improvements) used for inventory compilation are collected on the special server and the backup of data are made periodically. All information is archived at LEGMC. Common, password protected FTP folder is used for information storage and exchange.

Printed copies of NIR are stored in LEGMC and MEPRD archives in May each year, after completion and submission of the inventory. All information is archived on CDs as well.

#### 1.2.3.4 Verification activities

In the CSB data are verified in two data processing stages: on raw data level (processing of individual information) and on aggregated data level (verifying prepared aggregates).

CSB uses several methods for data verification at the raw data level:

- arithmetical connections;
- logical connections;
- comparison with data of previous periods;
- mutual coherence verification with other statistical questionnaires;
- statistical registers and administrative data.

Aggregates are made and different groupings are formed from the raw data produced. CSB uses similar methods for verification of aggregates to ones, which are applied in the verification of raw data.

#### 1.2.3.5 Treatment of confidentiality issues

For Latvia's GHG Inventory mainly confidentiality is related to activity data provided to LEGMC by CSB. The data then is used for emission estimation and can't be reported further. If the data that could be considered as confidential is provided to LEGMC by production plan or other enterprise then the data is not considered as confidential and can be reported within GHG Inventory.

Data of CSB

Legal, technical and administrative measures:

Legal:

"Law on State Statistics"

"Law on State Information Systems"

"Personal Data Protection Law"

"Information Publicity Law".

Technical:

Physical Security (environmental (temperature fluctuations, etc.), technical (voltage reduction, etc.) and human factors (theft, deliberate or unintentional damages, etc.).

Logical Security (security measures provided by IT: user names and passwords, antivirus, firewalls etc.).

Administrative:

Information Security Management Coordination Council (ISMCC) ensure and implement in the CSB security policy, security means and principles of data storage, information classification and confidentiality, principles of granting access rights.

Information Security Policy developed (2008).

CSB ensures confidentiality and protection of information supplied by the respondents, as well individual information received from other sources pursuant to the requirements of national legislation in force.

The CSB takes the necessary organisational, administrative and technical measures to ensure confidentiality.

**Technical:** described in internal regulations and procedures on security and use of Information Systems.

**Organisational and administrative:**

- "Confidentiality Statement" signed by every employee, laying down the personal data non-disclosure obligation;
- Confidentiality Council established to ensure that individual information possessed by the CSB is used for scientific and research purposes according to the provisions of the Official Statistics Law and other legal acts and to deal with legally unregulated confidentiality issues.
- Handbook of statistical confidentiality developed (2009) that provides explanations of the methods used by the CSB for ensuring data confidentiality.

It is strictly determined in Law of Statistics what information could be provided to other institutions even though the information is needed in emission estimation and reporting under international conventions. CSB can't give the information of amount of production if one or two companies produce up to 95% from total market production in particular sector.

Due to small market of Latvia almost all industrial production data is classified as confidential with some exceptions in food and drink sector. LEGMC has interdepartmental agreement with CSB to receive confidential information for the emission estimation but these activity data has to be reported as "C" in CRF Tables and in NIR.

Data of EU ETS

As all Latvia's industrial processes sector's companies are participating in EU ETS then data from these companies can be obtained from their annual GHG report within compliance obligations within EU ETS. These activity data used emission factors and used emission estimation methodologies can be reported in NIR and in CRF Tables as the data of EU ETS can't be confidential and all companies' annual GHG reports are published in LEGMC webpage.

ETR documentation

As no significant changes were done in Latvia's ETR then ITL Initialization documentation wasn't changed either.

### 1.2.4 Changes in national inventory arrangements since previous annual GHG inventory submission

There are no changes to arrangements with institutions involved in the GHG inventory preparation. The agreements regarding responsibilities are maintained and continue to be in force according to the national legislation (Regulations of the Cabinet of Ministers No. 217 adopted on 27 March 2012 "The National Inventory System of Greenhouse Gas Emission Units").

## *1.3 Inventory preparation, data collection, processing and storage*

### 1.3.1 GHG inventory and KP-LULUCF inventory

Each sector has an assigned one or more responsible sectoral experts who are responsible for conformity with the relevant reporting guidelines, selection of appropriate methods and data sources and activity data collection, processing and updating of data.

For the Energy (excluding Transport), IPPU and Waste – data collection and emission estimation is done by LEGMC experts from Air and Climate Division, Chemicals and Hazardous Waste Division and Inland Waters Division.

For Transport activity data is collected and emissions are calculated by expert from Institute of Physical Energetics.

For Agriculture, data collection and emission estimations are done by Latvia University of Agriculture in collaboration with Ministry of Agriculture.

Land-use, land use change and forestry data and KP- LULUCF data are collected and emissions/removals are calculated in Latvian State Forest Research Institute "Silava" in collaboration with Ministry of Agriculture and Latvia University of Agriculture.

All experts responsible for data collection and processing in a particular sector are preparing their data (activity data, emission factors) for import into CRF Reporter software.

## 1.4 Brief general description of methodologies and data sources used

### 1.4.1 GHG inventory

Latvia's GHG emissions inventory is based on:

- 2006 IPCC Guidelines;
- 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC Wetlands Supplement);
- 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC KP Supplement);
- EMEP/CORINAIR Guidebook 2007 and EMEP/EEA 2009;
- EMEP/EEA air pollutant emission inventory guidebook 2013.

The main sources for emission factors are guidelines mentioned above as well as national studies for country specific parameters and emission factors (e.g. $CO_2$ emission factors, aspects influencing $SO_2$ emission factors, distribution of animal waste management systems, average N excretion and etc.).

For 2016 submission (NIR and CRF tables) compilation the CRF Reporter version 5.14 was used. To calculate GHG emissions, supplemental locally developed database in Excel format was used for all sectors except for Road Transport where COPERT IV was used.

Where data of bottom – up method were available and plants had reported estimated data using plant specific emission factors and estimation methodologies for Energy sector, these data were used in the submission. If these data were not available, Tier 1 method from 2006 IPCC Guidelines was used to estimate emissions. Emissions for the whole country fuel consumption were estimated by adding up fuel consumption of individual sectors multiplied by appropriate emission factors.

Emissions from Road Transport sector were estimated by using COPERT IV model for 1990–2014 (Tier-2 method). Emissions for other transport sub-sectors were estimated according to IPCC Tier 1 and Tier 2 methodologies (Tier 2 method for diesel oil $CO_2$ emission calculation in railway and navigation and Tier 2 method for jet kerosene emission calculation in aviation (civil and international). Rest of emissions have been calculated by Tier 1 method).

Emissions from Industrial Processes and Product Use were estimated according to 2006 IPCC Guidelines, EMEP/CORINAIR 2007 Guidebook, EMEP/EEA 2009, EMEP/EEA air pollutant emission inventory guidebook 2013 as well as using expert research and judgment about activity data and emission factors.

Emissions from Agriculture sector were estimated according to methodologies from 2006 IPCC Guidelines, IPCC Wetlands Supplement additionally using local researches related some parameters.

2006 IPCC Guidelines, IPCC KP Supplement and IPCC Wetlands Supplement for $CO_2$, $CH_4$ and $N_2O$ emissions from drained and rewetted soils were used to estimate emissions from LULUCF and KP-LULUCF sector.

2006 IPCC Guidelines were used to estimate emissions from Waste sector.

The Table 1.3 presents the main data sources used for activity data as well as information on actual calculations:

**Table 1.3 Main data sources for activity data and emission values**

| Sector | Data Sources for Activity Data | Emission Calculation |
|---|---|---|
| Energy | Energy balance from Latvian Central Statistical Bureau (CSB);<br>IEA/ OECD – EUROSTAT – UNECE Annual questionnaires;<br>LEGMC "2-AIR" database;<br>Research of experts. | LEGMC Air and Climate division, plant operators |
| Transport | Energy balance from Latvian CSB;<br>IEA/AIE – EUROSTAT – UNECE Annual questionnaires;<br>Data of Road Traffic safety Directorate;<br>Research of experts. | IPE according to agreement with the Ministry of Environmental Protection and Regional Development |
| Industrial Processes and Product Use | National production and sales statistics;<br>Direct information from enterprises operating with pollutants;<br>Central Statistical Bureau;<br>Chemicals Register;<br>Assumptions by experts;<br>State Agency of Medicines;<br>Research by experts;<br>LEGMC "2-AIR" database | LEGMC Air and Climate division, plant operators<br>LEGMC Chemicals and Hazardous Waste division |
| Agriculture | National agricultural statistics obtained from CSB;<br>National studies. | Latvia University of Agriculture in collaboration with Ministry of Agriculture |
| LULUCF; LULUCF KP | National forest inventory<br>State forest service<br>Ministry of Agriculture of Republic of Latvia<br>Central Statistical Bureau<br>State Firefighting & Rescue Service<br>National studies and expert judgment | Latvian State Forest Research Institute "Silava" in collaboration with Ministry of Agriculture and Latvia University of Agriculture |
| Waste | Latvian Environment, Geology and Meteorology Centre "3-Waste" and "2-Water" databases;<br>Methane recovery installations;<br>CSB. | LEGMC Chemicals and Hazardous Waste division,<br>LEGMC Inland Waters Division |

### 1.4.2 KP-LULUCF inventory

The land use matrix is based on the results of land use changes to forest derived from the NFI of the period 2004-2008 and 2009-2013. Methodology for estimation of earlier land use changes, including deforestation activities is under development in the LSFRI Silava as a part of National Forest inventory (NFI). The assessment methods at the NFI grid points are described in Annex 1 of Report on improvement of QA/QC system in LULUCF sector in Latvia[10]. Estimation of afforested and deforested area in 2009-2013 is based on of the NFI data, 2014 is extrapolated for the 5 years average of previous years.

Historical figures of deforestation were estimated using remote sensing methods based on evaluation of LANDSAT satellite image series from 1990, 1995 and 2000 using ERDAS Imagine software. The NFI is the main data provider for the GHG reporting in LULUCF sector

[10] https://drive.google.com/open?id=0Bxv4jQ_04jXZdEhJVFJ4OVRPTkE

and Kyoto protocol Article 3, paragraph 3 and Article 3, paragraph 4 (Article 3.3 and 3.4) activities.

Forest soil properties (carbon stock in litter and mineral soil) in forest lands were determined in permanent 16 x 16 km grid of 95 sample plots of the 1st level forest monitoring programme. No soil carbon stock changes are considered in afforested lands, according to research data demonstrating insignificant carbon stock differences in forest land and grassland.

Methods for estimating carbon stock changes in forests (for Article 3.3 afforestation, reforestation, deforestation and Article 3.4 forest management) are the same as those used for the LULUCF inventory reported under the UNFCCC. Estimations of carbon stock changes in living biomass on forest land remaining forest in the 1st cycle of the NFI are based on measurements of radial increment of growing trees and calculation of actual potential increment of timber volume of all living trees; in the second and third, "floating" period increment is calculated as stock difference of living trees; mortality is accounted as the stock of trees changing status (destiny) from living trees to dead and left in the stand; harvesting stock is accounted as stock of trees changing status (destiny) to dead and extracted. The NFI data are harmonized with the State forest service data provided information by application of linear factor (+26 %) to the whole accounting period.

Since research data are available, historical figures (before 2004) on mortality are recalculated and provided in the inventory considering 20 years decay period for dead biomass, respectively; calculations are done for the period 1970-2014. Removals of $CO_2$ in living biomass on afforested areas are calculated on the base of weighted average of timber stock changes in 1-25 years old forest stands on non-forest lands.

No harvesting takes place in lands converted to forests; therefore no artificial emissions in living biomass are reported in this category. However if by some reasons (for instance, thinning) harvesting took place on afforested area it is also reported in national statistics and is included in Forest management related carbon stock changes.

Losses in living biomass due to deforestation are reported based on average growing stock figures were used to extrapolate average losses in living biomass due to deforestation. All biomass, including stem, branches and below-ground biomass is considered instantly oxidized.

Carbon stock changes in dead wood, litter and soils are reported under deforestation assuming that average carbon stock on forest lands remaining forest in dead biomass pools is instantly oxidizing during conversion, but carbon soil in mineral soils stabilizes in 20 years. For conversion to settlements it is assumed that 20 % of carbon in 0-30 cm deep soil layer turns into emissions in 20 years.

### 1.4.3 European Union Emission Trading Scheme (EU ETS) data

Latvia has fully implemented the Directive 2003/87/EC[11] of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community.

[11] *http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02003L0087-20140430&from=EN*

The European Union Emission Trading System (EU ETS) data obtained from annual emission reports submitted by operators to competent authority is used as source of activity and emission data for the GHG inventory particularly in Energy and Industrial Processes and Product use sectors. All emission reports for all years 2005-2015 are publicly available on the web page of competent authority and are fully available for the GHG inventory.

Latvia has implemented EU ETS and set all the requirements in 2003 and 2004 when amendments in Law On Pollution were made and all necessary Cabinet of Ministers regulations were approved for the stationary combustion installations – monitoring, reporting, verification and compliance obligations, setting the possibility of voluntary participation for the installations not exceeding thermal input of 20MW. In 2005 Latvia's Emission Trading Registry was developed and launched. Since that time 93 installations have received GHG permits. Operation of EU ETS in Latvia is ensured mainly by Ministry of Environmental Protection and Regional Development (MEPRD) and institutions under the supervision of MEPRD – State Environmental Service and its Environment State Bureaus that are responsible for approval of monitoring plans, issuance of permits, and approval of annual emission reports for stationary installations, Latvian Environment, Geology and Meteorology Centre that is Latvia's National Administrator of Emission Trading Registry (Union Registry since 2012).

Starting 2008 for Kyoto Protocol 1st period the EU ETS was linked to the international emissions trading under the Kyoto Protocol. The scope of EU ETS was enlarged still in Latvia no new installation was included in EU ETS due to enlarged scope.

Since 2012 the aviation activities were also included in EU ETS regarding all aircraft operators that perform flights to/from EU. Still in 2013 the exemptions were applied to the flights to/from countries outside European Economic Area (EEA) so in 2013-2016 only internal flights to/from EEA countries as well as to/from aerodromes in the same outermost region are included in EU ETS scope. Civil aviation agency (institution of Ministry of Transport) is main competent authority responsible for approval of monitoring plans and approval of annual emission reports for aircraft operators still MEPRD is fully responsible regarding the implementation of the requirements for the aviation activities in EU ETS.

Latvian National Accreditation Bureau (the institution of Ministry of Economy) is responsible for accreditation and monitoring of verifiers.

Starting 2013 in EU ETS Phase 3 the scope was again extended and one installation of Latvia was included in EU ETS. Starting this period, the emission allowances are mainly auctioned. New harmonised requirements for the calculation and allocation of EU allowances were developed by European Commission in 2011 as well as harmonised requirements for monitoring, reporting, accreditation and verification were developed by European Commission in 2012. Harmonised templates for monitoring plan, emission report (and tonnkilometer reports for aircraft operators), verification report as well as templates for emission allocation calculation and reporting were developed by European Commission. Latvia uses these developed harmonised templates. Since 2013 the calculation of EU allowances as well as the monitoring and control of annual allocation is done by MEPRD.

In 2014 there were 66 EU ETS installations in Latvia and 15 aircraft operators were set as administered by Latvia (only 2 aircraft operators were not exempted and was set as aircraft operators of EU ETS).

Unified emission trading registry system was developed and launched in 2012 so all EU Member States use the same registry for EU ETS compliance activities.

Latvia`s verified ETS emissions in 2014 were 2354,247 kt $CO_2$ eq.

## 1.5 Brief description of key categories, including for KP-LULUCF

### 1.5.1 GHG inventory

This section provides an overview of key categories. The identification of key categories is described in the 2006 IPCC Guidelines Chapter 4: Methodological Choice and Identification of Key Categories.

Key sources are the emissions/removals, which have a significant influence on the total inventory in terms of the absolute level of emissions and the trend of emissions or both. Level Assessment identify source category whose level has a significant effect on total national emissions. Trend Assessment identifies sources that are the key because of their contribution to the total trend of national emissions.

It is important to identify key source categories so that the resources available for inventory preparation may be prioritized and the best possible estimates prepared for the most significant source categories.

IPCC methodologies offer two different methods for identifying key sources: Approach 1 and Approach 2. In the Approach 1 method, the emission sources are sorted according to their contribution to emission level or trend. In the Approach 2 method, the relative uncertainties of the source categories are also taken into account. The key sources are the emission categories, which represent together 95% of the inventory uncertainty if using level and trend assessment and 90% of the total value of the total trend assessment with uncertainty.

For 2016 submission both approaches are used to identify key sources for time period 1990-2014. The identification was divided in two parts, key sources excluding LULUCF and key sources including LULUCF source categories. The starting point for the choice of source categories with LULUCF is the list presented in the 2006 IPCC Guidelines, Chapter 4 Methodological Choice and Identification of Key Categories, Table 4.1. The base year for $CO_2$, $CH_4$, and $N_2O$ greenhouse gas emissions was 1990.

Summary of key categories is shown in Table 1.4. Key categories are identified by Approach 1 and Approach 2 (level and trend) in order to provide additional insight into the reasons why particular categories are key. The mandatory, detailed reporting tables of the key categories (Tables 4.2 and 4.3 of volume 1 of the 2006 IPCC Guidelines, including and excluding LULUCF) are provided in Annex 1 of this submission.

**Table 1.4 Key categories in 2016 submission identified using Approach 1 and Approach 2 level and trend assessment**

| IPCC category/Group | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | T1 | X | X |

| IPCC category/Group | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | L1,T1 | | X |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | T1 | | X |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | T1 | X | X |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | T1 | | X |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | T1 | | X |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | T1 | X | X |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | L1,T1 | X | X |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | L1,T1 | X | X |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | L1 | X | X |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | T2 | | X |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | T2 | | X |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | L1,L2,T1 | X | X |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | L1,T1 | X | X |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | L2 | | X |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | L1,L2,T2 | | X |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | L1,L2,T1 | X | X |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | T1 | | X |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | L1,L2,T1,T2 | X | X |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | L1,L2,T1 | X | X |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | T2 | | X |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | L1,L2,T1 | X | X |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | L1,L2,T1,T2 | | X |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.B.2.b Natural Gas | $CH_4$ | L1,L2,T1,T2 | X | X |
| 1.B.2.c Venting and Flaring | $CH_4$ | L1 | | X |

| IPCC category/Group | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 2.A.1. Cement Production | $CO_2$ | L1,L2,T1,T2 | X | X |
| 2.A.2. Lime Production | $CO_2$ | T1,T2 | X | X |
| 2.A.4. Other process uses of carbonates | $CO_2$ | T1,T2 | | X |
| 2.C.1 Iron and Steel Production | $CO_2$ | T1 | | X |
| 2.D.3. Solvent Use | $CO_2$ | L1 | | X |
| 2.F.1. Refrigeration and air conditioning | HFCs | L1,L2 | X | X |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | L1,L2,T1,T2 | X | X |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | L1,L2,T1 | | X |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | L1,L2 | | X |
| 3.B.5 Indirect N2O emissions from Manure Management | $N_2O$ | L1,L2 | | X |
| 3.D.1. Direct N2O emissions from managed soils | $N_2O$ | L1,L2,T1,T2 | X | X |
| 3.D.2 Indirect N2O Emissions from managed soils | $N_2O$ | L1,L2,T1,T2 | X | X |
| 3.G. Liming | $CO_2$ | T1,T2 | X | X |
| 4. G. Harvested wood products | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood | $CO_2$ | L1,L2,T1,t2 | X | |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass | $CO_2$ | L1,T1,T2 | X | |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.A.1 Forest Land remaining Forest Land – Drained organic soil | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $N_2O$ | L1,L2,T1,T2 | X | |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | L1,L2,T1,T2 | X | |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CO_2$ | L2 | X | |
| 4.A.2 Land converted to Forest Land – Carbon stock change, grassland converted to forest land | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, dead wood | $CO_2$ | L1 | X | |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, litter | $CO_2$ | L1 | X | |
| 4.B. Cropland remaining cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | L1,L2 | X | |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – living biomass | $CO_2$ | L2 | X | |
| 4.B.1 Cropland remaining Cropland – Drained organic soil | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | T1 | X | |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | T2 | X | |
| 4.B.2 Land converted to Cropland – Carbon stock change, forest land converted to cropland | $CO_2$ | T1,T2 | X | |
| 4.B.2 Land converted to Cropland – Drained organic soil | $CO_2$ | L1,L2,T2 | X | |
| 4.B.2 Land converted to Cropland –Mineral soil | $CO_2$ | T2 | X | |

| IPCC category/Group | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 4.C. Grassland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | L1 | X | |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – living biomass | $CO_2$ | T2 | X | |
| 4.C.1 Grassland remaining Grassland – Drained organic soil | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.C.2 Land converted to Grassland – Drained organic soil | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.C.2 Land converted to Grassland –Mineral soil | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – living biomass | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – organic soils | $CO_2$ | L1,L2 | X | |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CO_2$ | L1,L2 | X | |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – living biomass | $CO_2$ | L1,L2,T2 | X | |
| 4.E.2 Land converted to Settlements – Carbon stock change – dead organic matter | $CO_2$ | L1,T1 | X | |
| 4.E.2 Land converted to Settlements – Carbon stock change – living biomass | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.E.2 Land converted to Settlements – Mineral soils | $CO_2$ | L1,L2,T1,T2 | X | |
| 4.E.2 Land converted to Settlements – Organic soils | $CO_2$ | L1,L2,T1,T2 | X | |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | L1,L2 | X | X |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | L1,L2,T1,T2 | X | X |
| 5.B.1. Composting | $CH_4$ | L2,T2 | | X |
| 5.B.1. Composting | $N_2O$ | L2,T2 | | X |
| 5.D.1 Domestic Wastewater | $CH_4$ | L1,L2,T1,T2 | X | X |
| 5.D.1 Domestic Wastewater | $N_2O$ | L2,T2 | | X |
| 5.D.2 Industrial Wastewater | $CH_4$ | L1,L2,T1,T2 | X | X |

### 1.5.2 KP-LULUCF inventory

There were several key categories in KP-LULUCF. The most significant key source of emissions in KP-LULUCF is $CO_2$ in forest management and due to deforestation. Other key sources of emission are $N_2O$ and $CH_4$ in forest management (forests on drained and rewetted organic soils).

## *1.6 General uncertainty evaluation*

### 1.6.1 GHG inventory

This section provides an overview of the approach to uncertainty analysis for Latvia's inventory.

The uncertainty estimates of the 2016 submission have been done according to the Approach 1 method presented in 2006 IPCC Guidelines. The Approach 1 is based on emission estimates and uncertainty coefficients for activity data and emission factors. The mandatory, detailed reporting tables of the uncertainty analysis (Table 3.3 of volume 1 of the 2006 IPCC Guidelines with and without LULUCF) are provided in Annex 2 of this submission.

2016 submission total uncertainties are reflected in Table 1.5.

**Table 1.5 Uncertainties of 2016 submission**

| | Uncertainty in total inventory % | Trend uncertainty % |
|---|---|---|
| **With LULUCF** | 16% | 11% |
| **Without LULUCF** | 7% | 2% |

In many cases uncertainty coefficients have been assigned based on default uncertainty estimates according to 2006 IPCC Guidelines or on expert judgment, because there is a lack of the information. For each source, the uncertainty for activity data and emission factors was estimated and given in per cent.

Generally for activity data from CSB 2% uncertainty is used according to received information from CSB.

The uncertainty calculation is based on Excel file, which is send to sectoral experts for updating annually.

The uncertainty analysis was done for the all sectors: Energy, Industrial Processes and Product Use, Agriculture, Waste and LULUCF. Uncertai. nties are estimated for direct greenhouse gases, e.g. $CO_2$, $CH_4$, $N_2O$ and F-gases only.

In the annual meeting at the beginning of the inventory cycle the experts are advised to go through the uncertainty ranges of activity data and emissions factors in order to prioritize inventory improvements. This year the uncertainty categories were reviewed and disaggregated according to 2006 IPCC Guidelines.

Detailed about uncertainty assessment is described under each subsector.

### 1.6.2 KP-LULUCF inventory

Tier 1 was implemented for estimating uncertainty rates related to activity data and emission factors employed in the estimates under Article 3.3. activities.

## *1.7 General assessment of completeness*

### 1.7.1 GHG inventory

Latvia has provided estimates for all significant IPCC source and sink categories according to the detailed CRF classification. Estimates are provided for the following gases: $CO_2$, $N_2O$ $CH_4$, F-gases (HFC, PFC, $SF_6$ and $NF_3$), NMVOC, NOx, CO and $SO_2$. No additional sources and sinks identified.

In accordance with the IPCC Guidelines, international aviation and marine bunker fuel emissions are not included in national totals.

The notation keys presented below are used to fill in the blanks in all the tables in the CRF. Notation keys used in the NIR are consistent with those reported in the CRF.

*NE (not estimated):*

"NE" is used for existing emissions by sources and removals by sinks of greenhouse gases that have not been estimated.

*IE (included elsewhere):*

"IE" is used for emissions by sources and removals by sinks of greenhouse gases that have been estimated but included elsewhere in the inventory instead of the expected source/sink category.

*NA (not applicable):*

"NA" is used for activities in a given source/sink category that do not produce emissions or emissions are negligible.

*C (confidential):*

"C" is used for emissions that could lead to the disclosure of confidential information classified in the national legislation if reported at the most disaggregated level. In this case a minimum of aggregation is required to protect business information.

### 1.7.2 KP-LULUCF inventory

The National forest inventory as well as other statistical data sources covers the whole territory of Latvia, therefore, the GHG inventory represents the whole country. All sources and sinks included in the IPCC Guidelines are covered.

### 1.7.3 Completeness by timely coverage

Both direct GHGs as well as indirect GHGs are covered by the Latvia's inventory. A complete set of CRF tables are provided for all years and the estimates are calculated in a consistent manner.

# 2 TRENDS IN GREENHOUSE GAS EMISSIONS

Detailed information on emission trends is provided in the description of IPCC sectors in chapters 3-7 and in the CRF trend tables.

## *2.1 Description and interpretation of emission trends for aggregated greenhouse gas emissions*

The aggregated greenhouse gas emissions include gases defined in the Kyoto protocol – carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), sulphur hexafluoride ($SF_6$), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and nitrogen trifluoride ($NF_3$). The emission levels are presented in kt of carbon dioxide equivalents (kt $CO_2$ eq.).

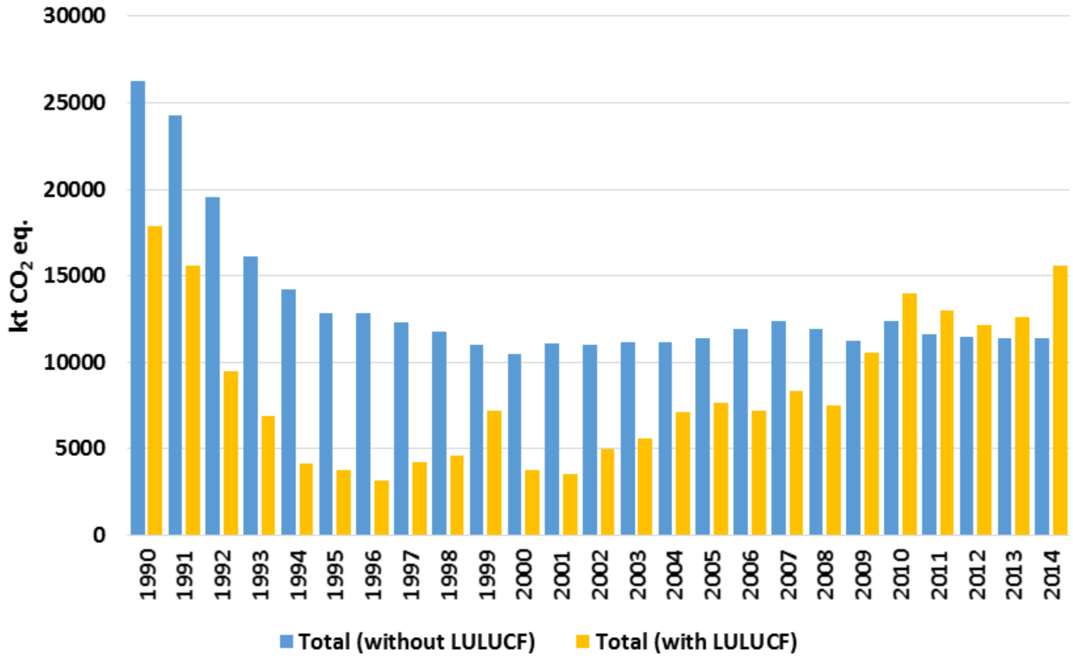


**Figure 2.1 Latvia`s aggregated greenhouse gas emissions in 1990-2014 (kt $CO_2$ eq.)**

As illustrated in Figure 2.1, since 1990 Latvia's GHG emissions have considerably decreased by 56.76% (excluding LULUCF) and by 12.68% including LULUCF. This decrease is influenced the economic situation in the country. In Latvia the transition period to market economy started after 1991. This process provoked essential changes in all sectors of national economy and resulted in the decrease of GHG emissions after 1990.

The GHG emissions in LULUCF sector, in contrast, continuously increased since 1990. These changes are driven mostly by reduction of $CO_2$ removals in living biomass due to ageing of forests, increasing of mortality in mature forests. If compared to 1990, both figures are doubled since 1990; respectively, average mortality rate in forest in 1990 was 1.61 $m^3$ $ha^{-1}$ annually, now (in 2014) it is 2.31 $m^3$ $ha^{-1}$ annually, but felling rate in 1990 was 6.3 mill. $m^3$ annually, now it is 16.6 mill. $m^3$ annually. LULUCF sector is also heavily affected by land use changes – in nineteenths considerable area of afforested lands were converted back to agricultural production, in the recent decade another trend is growing – conversion of forest land to settlements to build roads, industrial centers and other infrastructure.

## *2.2 Description and interpretation of emission trends by gas*

Carbon dioxide ($CO_2$) is the main greenhouse gas causing the climate change. In 2014, $CO_2$ emissions constitute 62.9% of Latvia's total greenhouse gas emissions. In 2014, total $CO_2$ equivalent emissions without land use, land-use change and forestry had decreased by approximately 63.8% since 1990.

The most important source of $CO_2$ emissions (kt) in 2014 was fossil fuel combustion – 91.0%, including Energy Industries – 23.3%, Manufacturing Industries and Construction – 9.6%; Transport – 40.5%, Other sectors (Agriculture, Forestry, etc.) – 17.5%.

Other anthropogenic emission sources of $CO_2$ are Industrial Processes and Product Use – 8.6%, Agriculture 0.3% and Waste 0.01 %.

Main sources of $CH_4$ emissions in Latvia are Enteric Fermentation of Livestock, Solid Waste Disposal Sites and Energy sector. Other important sources of $CH_4$ emissions are leakage from natural gas pipeline systems and combustion of biomass. $CH_4$ emissions in 2014 contribute approximately 18.3% of total GHG emissions (excluding LULUCF). The methane emissions (kt) decreased by 43.3% in 2014 since 1990.

Agricultural soils are the main source of $N_2O$ emissions in Latvia generating 86.8% of all $N_2O$ emissions (kt) in 2014. Other $N_2O$ emission sources are transport and biomass, combustion of liquid and other solid fuels in sectors of energy conversion and industry, waste and sewage. Since 1990, total $N_2O$ emissions had decreased by 34.0% in 2014, mainly due the decrease in the emissions from agriculture.

Emissions from HFCs and sulphur hexafluoride ($SF_6$) consumption are reported for the period 1995-2014. Total HFCs emissions (kt $CO_2$ eq.) increased by 3.8% in 2014 compared with 2013. Since 1995 HFC emissions have increased by 1744%. $SF_6$ emissions from electrical equipment contribute 8.58 kt $CO_2$ eq in 2014. Emissions of the PFCs and $NF_3$ does not occur (NO) in Latvia for all time series.

Emissions by sources are illustrated in the following Figure 2.2.

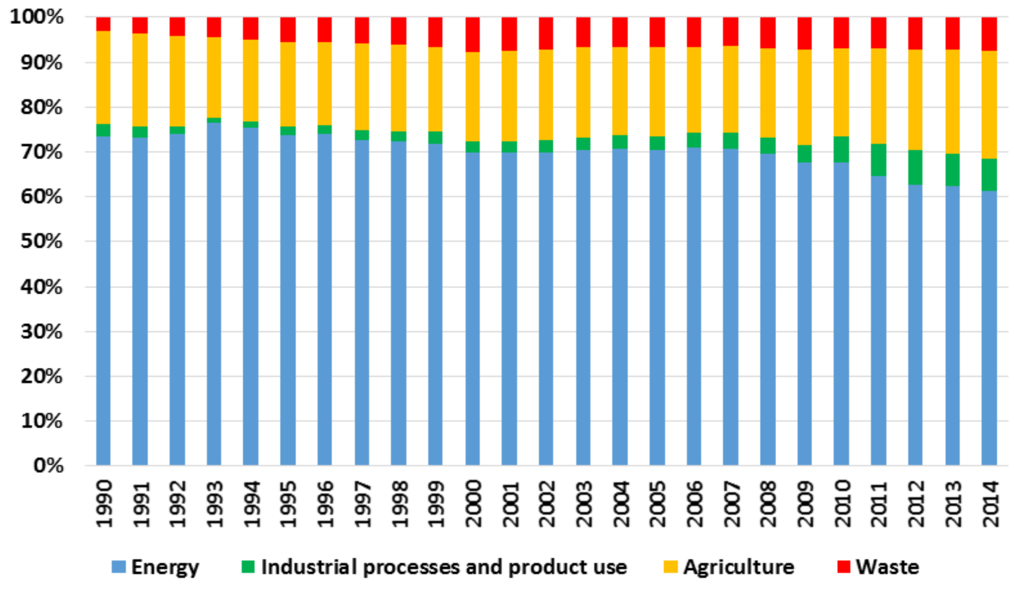


**Figure 2.2 Latvia`s greenhouse gas emissions by source 1990-2014 excluding LULUCF**

## *2.3 Description and interpretation of emission trends by category*

### 2.3.1 Trends in ENERGY

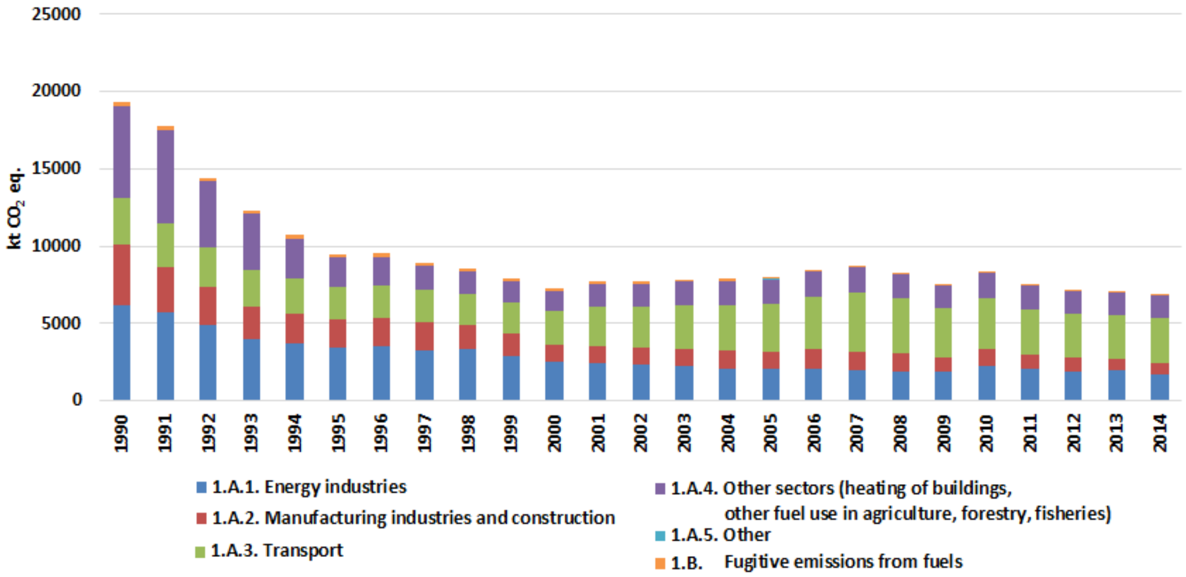


**Figure 2.3 Trend in GHG emissions from Energy sector in 1990-2014 (kt $CO_2$ eq.)**

There are two types of emission categories within Energy sector – fuel combustion, where emissions from Energy Industries (CRF 1.A.1), Manufacturing Industries and Construction (CRF 1.A.2), Transport (CRF 1.A.3), Other sector (CRF 1.A.4) and Other (military activities; CRF 1.A.5) sector are produced, and fugitive emissions (CRF 1.B) where leakages from oil distribution and natural gas are occurring. As it can be seen in Figure 2.3, the Energy sector (CRF 1.A, 1.B) is the most significant source of GHG emissions with 73.4% share of the total emissions in 1990 and 61.2% share in 2014. Most of Energy sector emissions (98.7% from total Energy emissions in 1990, and 98.1% in 2014) are produced by combusting fuels (CRF 1.A).

Emissions have decreased in all Energy subsectors – the largest decrease can be seen in Manufacturing industries and Construction (CRF 1.A.2), where emissions in 1990-2014 have decreased by 81.5%. Also in Other sector (CRF 1.A.4) which includes Commercial/Institutional, Residential and Agriculture/Forestry/Fisheries the decrease in GHG emissions is 75.4%, and in in Energy Industries GHG emissions have decreased by 72.9%. In Fugitive sector the decrease in GHG emissions is 45.3%.

After the decreasing in the period 1990 -1999, total GHG emissions from Transport (CRF 1.A 3) had the rapid growth in the period 2000 – 2007 (Figure 2.4). Peak of GHG emissions in transport sectors have been recognized in 2007 when emissions exceeded 1990 level by 27.1%. The main reason for this increasing of emissions was a sharp growth of economy and income of population resulting in rapid increasing of cars (mainly passenger cars).

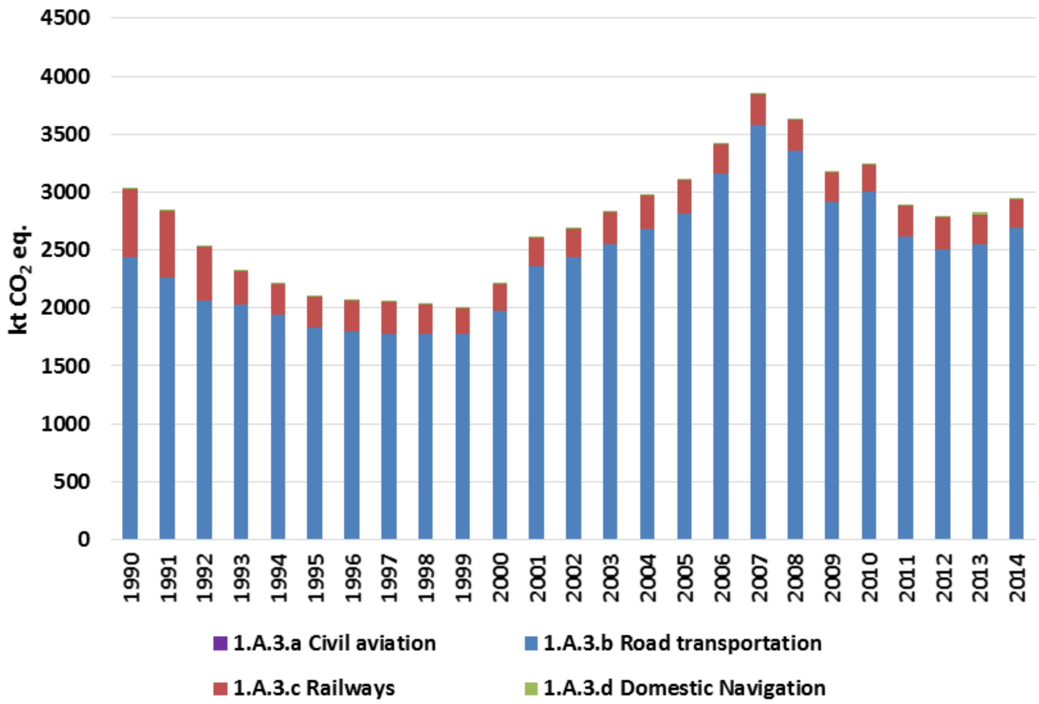


**Figure 2.4 GHG emissions development in transport 1990 – 2014 (kt $CO_2$ eq.)**

Recession of the national economy was the major reason for decreasing of transport activities – decrease of passenger km by passenger cars and ton km by freight transport - and corresponding GHG emission decreasing in the time period 2008 – 2009. We can recognize stability in GHG emission trend of transport sector in the last 3 years.

In 2014, total GHG emissions in the transport sector, compared 1990 level, have decreased by 2.6%, however emissions have increased by around 4.3% compared to 2013.

## 2.3.2 Trends in INDUSTRIAL PROCESSES AND PRODUCT USE

Figure 2.5 shows the GHG emission trend in IPPU sector.

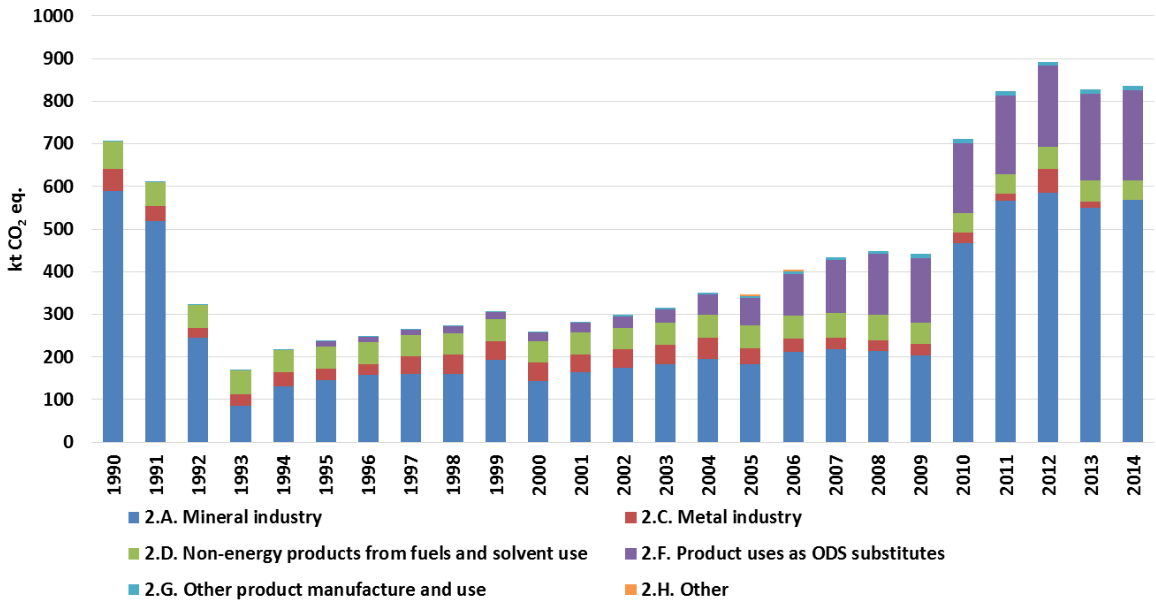


**Figure 2.5 Trend in GHG emissions from IPPU sector in 1990-2014 (kt $CO_2$ eq.)**

Largest part of GHG emissions in the Industrial Processes and Product Use (IPPU) sector constitute $CO_2$ emissions from 2.A Mineral industry (92.5 % of total $CO_2$ emissions from IPPU sector and 8.0% from total $CO_2$ emissions in 2014). The second largest source is 2.F Product Uses as ODS Substitutes causing 25.3% from all IPPU emissions and 1.9% from total GHG emissions in 2014. Considerably smaller are rest of IPPU emission sources – 2.G Other Product manufacture and use, 2.D Non energy products from fuels and solvents use and 2.C Metal industry constituting together 6.8% from entire IPPU emissions in 2014.

Compared to 2013 emissions from IPPU sector in 2014 have increased by about 1.0% and mainly it can be explained with different production and services demand in external market as well as with increasing consumption of refrigerants in refrigeration and air conditioning.

Data on emissions in IPPU sector are linked with the economic situation of the country as well as availability of statistical data. The largest decrease of emissions occurred between 1990 and 1993 when industry was affected by a crisis. It has to be noted that in the beginning of 1990s during the countrywide change in government system and national economy statistics was not well kept. Therefore there is a lack of statistical data regarding industry during this time period or they are vague.

As it is seen in Central statistics data, in 1998-2000 there were markably decreased export of products from Latvia to Commonwealth of Independent States (CIS) countries. GHG emissions from IPPU sector have increased from 260.31 kt $CO_2$ eq in 2000 to 892.51 kt $CO_2$ eq in 2012. It can be explained with sharp development of Latvian industry when construction activities increased and industrial production of building materials also increased.

Due to Latvia's economic features since 2007–2008 the industry development was slowing down as the financing and real estate sectors started dominating in national economy. In 2009-2010 emissions increased in mineral industry sector due to cement production plant switched the production technology and installations and increased its capacity by approximately 2.4 times.

### 2.3.3 Trends in AGRICULTURE

Agricultural GHG emissions in Latvia consist of $CH_4$ emissions from enteric fermentation of domestic livestock, $CH_4$ and $N_2O$ emissions from manure management, $N_2O$ emissions from agricultural soils and $CO_2$ emissions from liming and urea application. The trend of emissions in $CO_2$ eq. by category is presented in

Figure 2.6. Generally emissions from the agricultural sector have declined by 50.0% compared to 1990, due to the decrease of livestock population, crop production and amounts of synthetic fertilizer consumption.

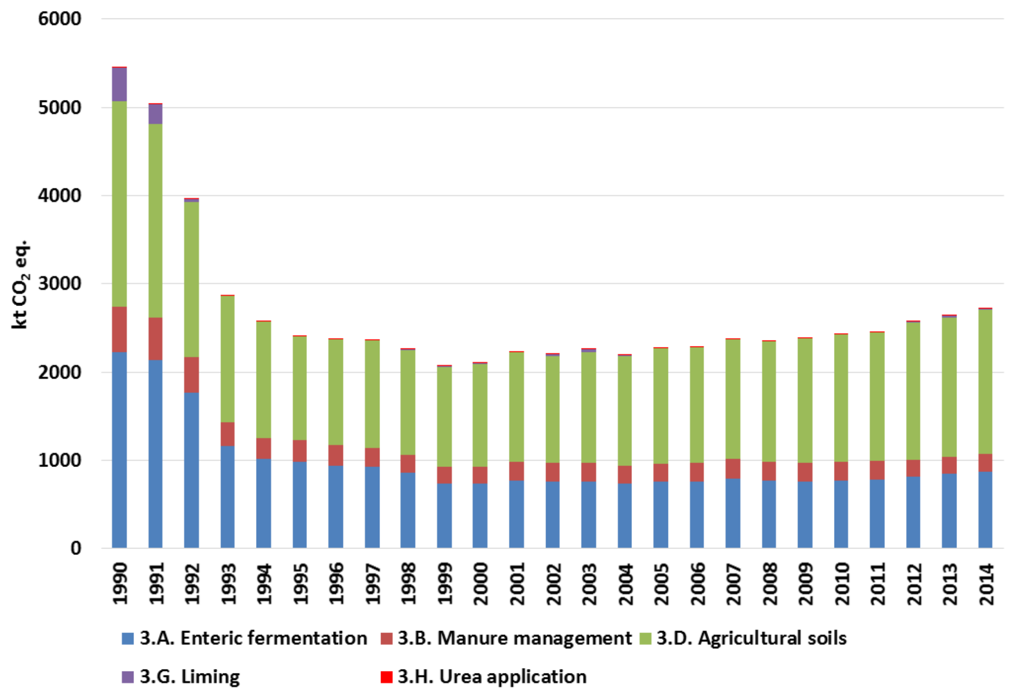


**Figure 2.6 Trends of emissions by category within the sector, 1990-2014 (kt $CO_2$ eq.)**

In 2014, agriculture sector contributed 24.0% of the total GHG emissions originated in Latvia or 2726.4 kt $CO_2$ eq. Emissions from agricultural soils contributed major share of the total emissions from the sector – 59.6%, enteric fermentation emissions was second largest source from the sector – 32.0%. The share of manure management emissions was evaluated as 7.5% of total emissions in the sector, remaining 0.9% of emissions refer to liming and urea application. GHG emissions increased in 2014 by 3.3% comparing to 2013 due to increase of cattle, sheep and fur animal numbers. Statistics also showed increase of synthetic N fertilizer consumption (+4.6%), sown area (+0.3%) and lime application to soils (+42.9%).

### 2.3.4 Trends in LULUCF

Net aggregated emissions in LULUCF sector considerably increased since 1990 due to growth of economic activity in forest sector and due to conversion of forest lands to settlements and croplands. The land use conversion to cropland is associated mostly to removal of woody vegetation from naturally afforested farmlands abandoned in 1980s. Although the increment of living biomass in forest land remaining forest and afforested land is still larger than the carbon losses due to commercial felling and natural mortality, the gap between gains and losses is decreasing, causing reduction of the net removals of $CO_2$ in forest land. Hence the total growing stock of living biomass is still increasing in forest lands. Summary of the net emissions including harvested wood products is shown in Figure 2.7. Increase of the GHG emissions in 2014 is associated with increase of the harvesting rate, increase of mortality and reduction of increment in forest lands as well as implementation of floating NFI cycle included in the calculations in 2014.

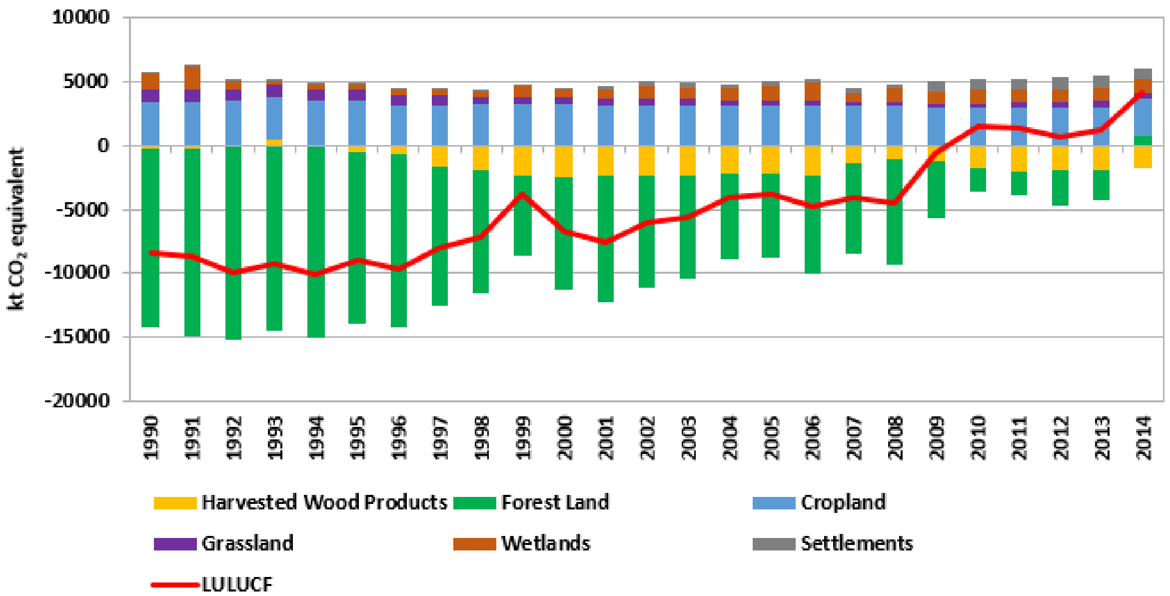


**Figure 2.7 Summary of the net emissions in LULUCF sector (kt $CO_2$ eq.)**

Absolute increase of the net annual GHG emissions in LULUCF sector in 2014 if compared to 1990 is 12641.77 kt $CO_2$ eq., mostly because of reduction of the net $CO_2$ removals in living biomass in forest lands (by 14752.66 kt $CO_2$ eq. between 1990 and 2014). Emissions increased also in settlements – by 783.84 kt $CO_2$ eq. between 1990 and 2014. In cropland, grassland and wetlands emissions decreased by, respectively 528.97, 484.58 and 232.77 kt $CO_2$ eq. annually between 1990 and 2014. Reduction of emissions in cropland is caused by conversion of cropland to grassland. Net decrease of annual removals in LULUCF sector in 2014 in compare to 1990 is 150 %.

### 2.3.5 Trends in WASTE

GHG emissions from Waste sector have been fluctuated from 1990-2014. Fluctuations in total GHG emissions in waste sector could be explained with changes of economic situation in last 20 years (Figure 2.8).

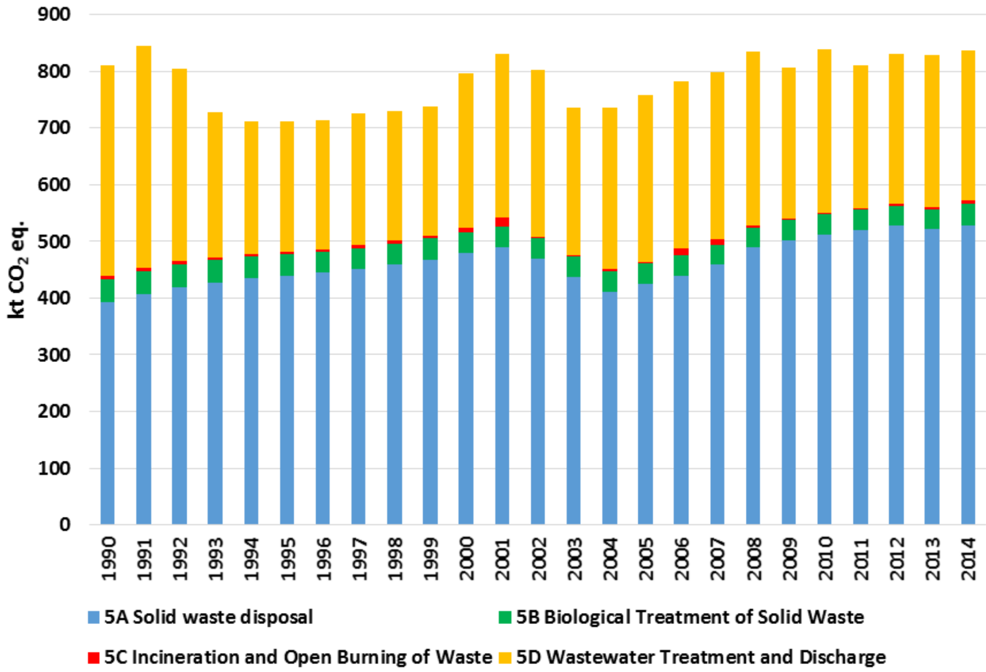


**Figure 2.8 Trend in GHG emissions from Waste sector in 1990-2014 (kt $CO_2$ eq.)**

Some industry sectors were almost closed in the middle of 1990s. Emissions from Biological treatment of solid waste and Incineration and open burning of waste are very small in comparison to 5.A. and 5.D.

In 2014, emissions were approximately 3.2% higher than in 1990. In 2014, emissions from the Waste sector were 836.99 kt $CO_2$ equivalent; it contributes about 7.4% of total GHG emissions (excluding LULUCF).

## *2.4 Description and interpretation of emission trends of indirect greenhouse gases and $SO_2$*

The emissions trends of the indirect greenhouse gases, sulphur dioxide, nitrogen oxides, carbon monoxide and non-methane volatile organic compounds, are presented in Figure 2.9.

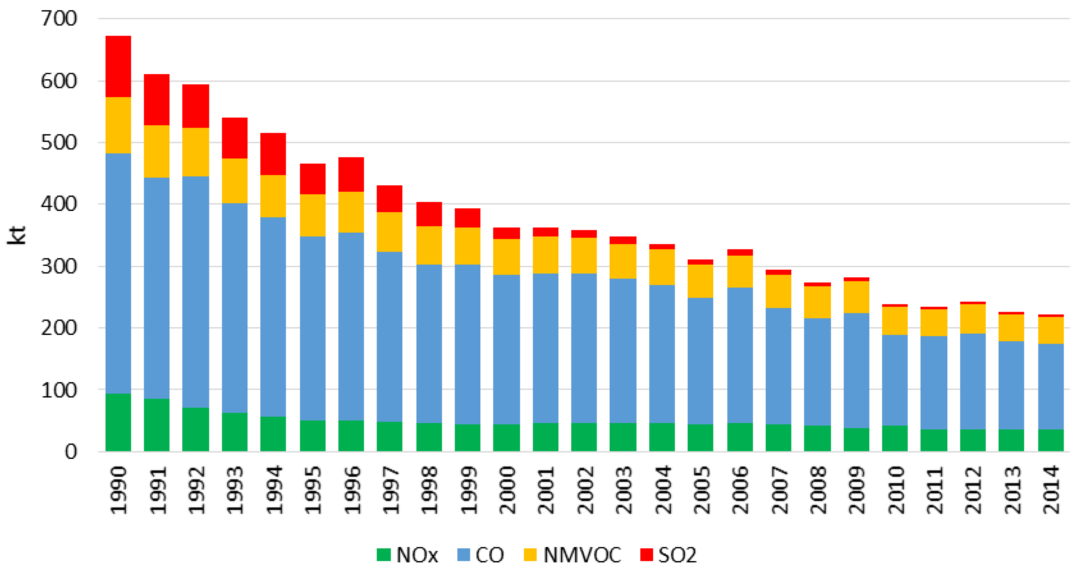


**Figure 2.9 Total indirect greenhouse gas emissions trend 1990-2014 (kt)**

In 2014, the **sulphur dioxide emissions** were 3.76 kt from which 96% originated in the Energy sector and 4% from IPPU. Since 1990 to 2014 the total $SO_2$ emissions have decreased by 96%. The reduction is mainly due to use of fuels with lower content of sulphur as well as fuel switching from solid and liquid types of fuel to natural gas and biomass.

**Emissions from nitrogen oxides** were 35.20 kt in 2014. 86% of NOx emissions generated in the Energy sector, 8% in Agriculture and 5% in IPPU. The Transport sector was responsible for 45% of the total $NO_x$ emissions. The total NOx emissions have decreased by 62% from 1990 to 2014. Generally the reduction is due to decrease of total fuel consumption that was caused by transformation of national economy as well as energy efficiency and control measures and also solid fuels and heavy liquid fuels replacement with natural gas and biomass fuels.

**Carbon monoxide** emissions were 138.44 kt, being produced generally in the Energy sector (91%). Other sectors (include heating of buildings, other fuel use in agriculture, forestry, fisheries) generate the biggest part of the total CO emissions – 71%. The CO emission trend shows a decrease of emissions for period 1990 – 2014 by 64%.

Total emissions of **non-methane volatile organic compounds** were 44.69 kt from which 48% are generated in Energy sector (mainly residential stationary plants) ) and 36% comes from IPPU (mainly from Non-energy products from fuels and solvent use which constitute 33% from total NMVOC emissions in 2014).

Emission consistency with the data used to prepare inventories of air pollutants under EU Directive 2001/81/EC and CLRTAP are checked.

## 2.5 Description and interpretation of emission trends for KP-LULUCF activities

Coverage of reporting of carbon pools and emission sources with regard to activities afforestation (A), reforestation (R) and deforestation (under Article 3.3) and optional activity forest management (FM) (under Article 3.4) are presented in Table 2.1. All mandatory carbon pools and sources are reported.

**Table 2.1 Information table relating to Article 3.3 and elected activities under Article 3.4**

| Activity | | Change in carbon pool reported | | | | | GHG sources reported | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Above-ground biomass | Below-ground biomass | Litter | Dead wood | Soil | Fertilization | Drainage of soils under forest management | Disturbance associated with land-use conversion to croplands | Liming | Biomass burning | | |
| | | | | | | | $N_2O$ | $N_2O$ | $N_2O$ | $CO_2$ | $CO_2$ | $CH_4$ | $N_2O$ |
| A 3.3 | A/R | R | R | R | R | R | NO | | | NO | NO | NO | NO |
| | D | R | R | R | R | R | | | NO | NO | NO | NO | NO |
| A 3.4 | FM | R | R | R | R | R | NO | R | | NO | R | R | R |
| | CM | NA | NA | NA | NA | NA | | | NA | NA | NA | NA | NA |
| | GM | NA | NA | NA | NA | NA | | | | NA | NA | NA | NA |
| | RV | NA | NA | NA | NA | NA | | | | NA | NA | NA | NA |

*R (reported), NR (not reported), IE (included elsewhere), NO (not occurring), NA (not applicable)*

The net emissions due to deforestation increases during the recent years due to active economic growth (building of roads and other infrastructure) in Latvia. Afforestation rate has decreased during recent years, however, accumulation of carbon in afforested areas continues to grow due to higher increment rates. The net $CO_2$ removals due to forest management decreased considerably during recent years due to increase of farvesting stock (by about 14 % in 2014 in comparison to 2013) and natural mortality (by 17 % in 2014 in comparison to 2009-2013) as well as due to decrease of increment of living trees (by 3 % in 2014 in comparison to 2009-2013). The changes in mortality and increment are mainly associated with ageing of forests. Considering predominance of mature forests declining of increment and increase of the natural mortality is predicted also in the following decades.

# 3 ENERGY (CRF 1)

## 3.1 OVERVIEW OF SECTOR

### 3.1.1 Quantitative overview

Energy sector is the main emission source in Latvia`s GHG inventory in 2014 (Figure 3.1). In total, Energy has created 61.2% of all GHG emissions (excluding LULUCF), and largest part of it contributes to Transport sector (almost half of Energy GHG emissions). As Latvia is located on temperate climate zone, heat production is an essential part of Latvia's economy, thus having an impact on GHG and air pollutant emissions.

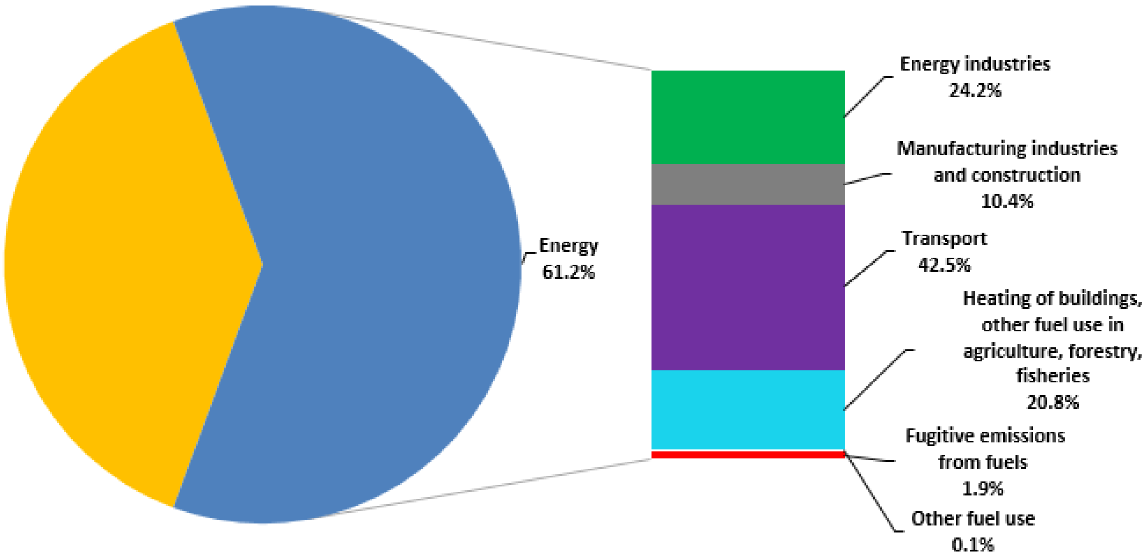


**Figure 3.1 Emissions from the Energy sector compared with the total emissions in 2014**

Energy consists of two subsectors – fuel combustion (98.1%) including stationary combustion and transport emissions, and fugitive emissions (1.9%), where emissions from non-combustion processes of fuels are reported, e.g., leakages from natural gas and diffuse emissions from gasoline.

In fuel combustion, the largest part of GHG emissions is generated in Transport sector (CRF 1.A.3; 42.5%). Stationary combustion contributes to 55.6% of all Energy emissions: 24.2% are produced by Energy industries (CRF 1.A.1), 20.8% - by Other sectors (CRF 1.A.4) where heating of buildings (small combustion installations in institutions and households) and other fuel use in agriculture, forestry and fisheries are included, and 10.4% by Manufacturing industries and construction (CRF 1.A.2). There are also emissions from offroad vehicles in military sectors, and these are reported under Other (CRF 1.A.5; in the figure above depicted as Other fuel use). These emissions contribute to 0.1% from all Energy emissions.

In the following sections of Energy chapter both emissions from fuel combustion and fugitive emissions are described.

As it can be seen in Figure 3.2, the share of subsectors in the Energy sector has changed, especially in 1.A.3 Transport sector, 1.A.4 Other sectors and 1.A.1. Energy industries and these changes are explained in the corresponding sub-chapters.

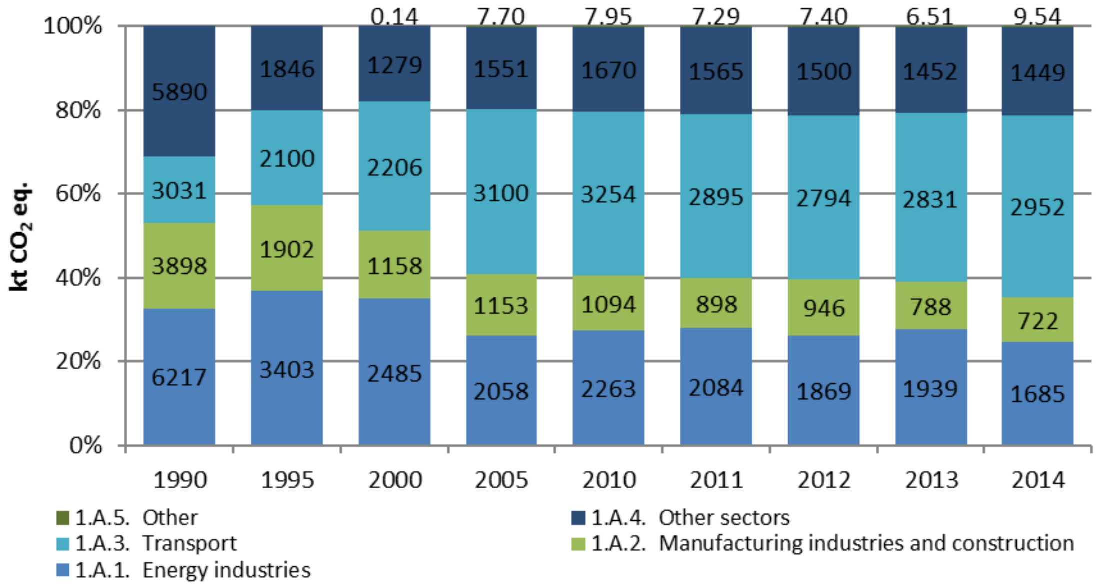


**Figure 3.2 Share of emissions in the Energy sector in 1990-2014 (%; kt $CO_2$ eq.)**

In 1990 the biggest share of GHG emissions was held by Energy industries with 32.7% as well as Other sectors with 30.9% from all emissions produced in Energy sector. 20.5% of emissions occured also in Manufacturing industries and construction sector, and the smallest share of emissions was held by Transport sector with only 15.9%. Emissions in military sector (1.A.5) were not produced until 1996.

However, starting from 1990, the share of Transport emissions have constantly grown, reaching 39.4% in 2005. Since then, the Transport sector have been the largest emissions' producer in Energy sector, which can be generally explained with the increase of population's income and growth of economy and also with restrictions related with use of fossil fuels in stationary combustion.

In 2014, the biggest share of GHG emissions in Energy sector is held by Transport sector with 43.3% of total Energy sector's GHG emissions. The second largest subsector with 24.7% share is Energy Industries, and a quite significant part of emissions – 21.3% – is produced within 1.A.4 Other sectors (small combustion in commercial and residential subsectors). Emissions from Military sector (1.A.5) have a 0.1% share from Energy emissions.

**Table 3.1 GHG emissions from Energy sector in 1990–2014 (kt)**

| | A Fuel combustion | | | B Fugitive emissions from fuels | | Aggregate GHGs |
|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $CO_2$, $CH_4$, $N_2O$ |
| | kt | | | kt | | kt $CO_2$ equivalent |
| **1990** | 18610.69 | 10.04 | 0.59 | 0.0115 | 9.9033 | 19283.59 |
| **1991** | 17069.02 | 10.86 | 0.63 | 0.0111 | 9.5390 | 17767.42 |
| **1992** | 13825.39 | 9.61 | 0.51 | 0.0101 | 8.6967 | 14434.58 |
| **1993** | 11751.15 | 10.13 | 0.43 | 0.0097 | 8.3172 | 12339.12 |
| **1994** | 10145.15 | 9.97 | 0.38 | 0.0094 | 8.1275 | 10710.49 |
| **1995** | 8888.66 | 10.11 | 0.36 | 0.0092 | 7.9150 | 9447.74 |
| **1996** | 8952.46 | 10.33 | 0.38 | 0.0089 | 7.6267 | 9513.29 |
| **1997** | 8407.06 | 9.80 | 0.38 | 0.0083 | 7.1182 | 8943.56 |
| **1998** | 8026.27 | 8.95 | 0.36 | 0.0079 | 6.8299 | 8528.63 |

| | A Fuel combustion | | | B Fugitive emissions from fuels | | Aggregate GHGs |
|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $CO_2$, $CH_4$, $N_2O$ |
| | kt | | | kt | | kt $CO_2$ equivalent |
| **1999** | 7409.80 | 8.81 | 0.34 | 0.0076 | 6.5111 | 7893.77 |
| **2000** | 6824.57 | 8.18 | 0.33 | 0.0070 | 6.0255 | 7278.72 |
| **2001** | 7223.51 | 9.06 | 0.36 | 0.0073 | 5.8433 | 7703.47 |
| **2002** | 7226.14 | 8.75 | 0.37 | 0.0074 | 6.1026 | 7707.29 |
| **2003** | 7403.02 | 8.94 | 0.40 | 0.0055 | 4.7631 | 7863.85 |
| **2004** | 7419.38 | 9.19 | 0.42 | 0.0055 | 4.7148 | 7892.21 |
| **2005** | 7514.06 | 9.07 | 0.44 | 0.0062 | 5.3272 | 8003.77 |
| **2006** | 7987.58 | 8.75 | 0.44 | 0.0044 | 3.8209 | 8433.73 |
| **2007** | 8304.80 | 8.73 | 0.46 | 0.0046 | 3.9225 | 8758.30 |
| **2008** | 7882.52 | 7.78 | 0.43 | 0.0047 | 4.0278 | 8305.10 |
| **2009** | 7154.60 | 8.43 | 0.42 | 0.0044 | 3.8050 | 7584.11 |
| **2010** | 7983.97 | 7.15 | 0.42 | 0.0043 | 3.6642 | 8379.65 |
| **2011** | 7143.86 | 7.04 | 0.43 | 0.0054 | 2.5212 | 7511.33 |
| **2012** | 6791.66 | 7.64 | 0.45 | 0.0049 | 3.1843 | 7195.26 |
| **2013** | 6700.16 | 7.14 | 0.46 | 0.0080 | 4.0400 | 7117.63 |
| **2014** | 6499.67 | 7.02 | 0.48 | 0.0138 | 5.4127 | 6952.97 |
| **2014 vs 2013** | -3.0% | -1.8% | 3.4% | 72.2% | 34.0% | -2.3% |
| **2014 vs 1990** | -65.1% | -30.1% | -18.2% | 19.8% | -45.3% | -63.9% |

Decrease of emissions depends on economic and social situation in the beginning and ending of the 1990s. The emissions have decreased from 1990 to 2014 with some fluctuations in between. From 2000 to 2010, fuel consumption as well as emissions from fuel combustion increased due to development of national economy, and after 2010 the emissions decreased (Table 3.1).

GHG emissions from the Energy sector in the latest years (since 2000) are fluctuating with a peak point in 2007 that is explained with an increase of national economy (Figure 3.3). GHG emissions in the Energy sector increased by 20.3% in 2000-2007. In the second half of 2008, a recession of the national economy started, caused by the global economic crisis. Decrease in economic output is the main reason why all GHG emissions in Energy sector decreased by 13.4% in 2007-2009. Starting with 2010, total GHG emissions increased again by 10.6% compared with 2009 as consumption of fuel increased; also due to the relatively warm winter – in 2009 the number of heating degree days[12] was 4184, while in 2010 – 4671. However, the emissions decreased again by 10.5% in 2011 compared to 2010 because of warm weather – the number of HDD was 3989. In 2012 fuel consumption decreased even more as well as the amount of GHG emissions produced – by 4.1% from 2011 level, however, the number of HDDs was considerably larger (HDD = 4385), which could be explained with better heat insulation in buildings. In 2013, the emissions were by 1.1% lower than in 2012, and also the number of HDDs was lower. In 2014 there can be seen the same trend as in 2013 – the emissions were by 2.3% lower and the number of HDDs were by 1.9% lower.

[12] *Heating degree day (HDD) is a proxy for the energy demand needed to heat a home or a business; it is derived from measurements of outside air temperature. The heating requirements for a given structure at a specific location are considered to be to some degree proportional to the number of HDD at that location. HDD are defined relative to a base temperature (18°C, according to EUROSTAT), the outside temperature below which a building is assumed to need heating (http://www.eea.europa.eu/data-and-maps/indicators/heating-degree-days-1).*

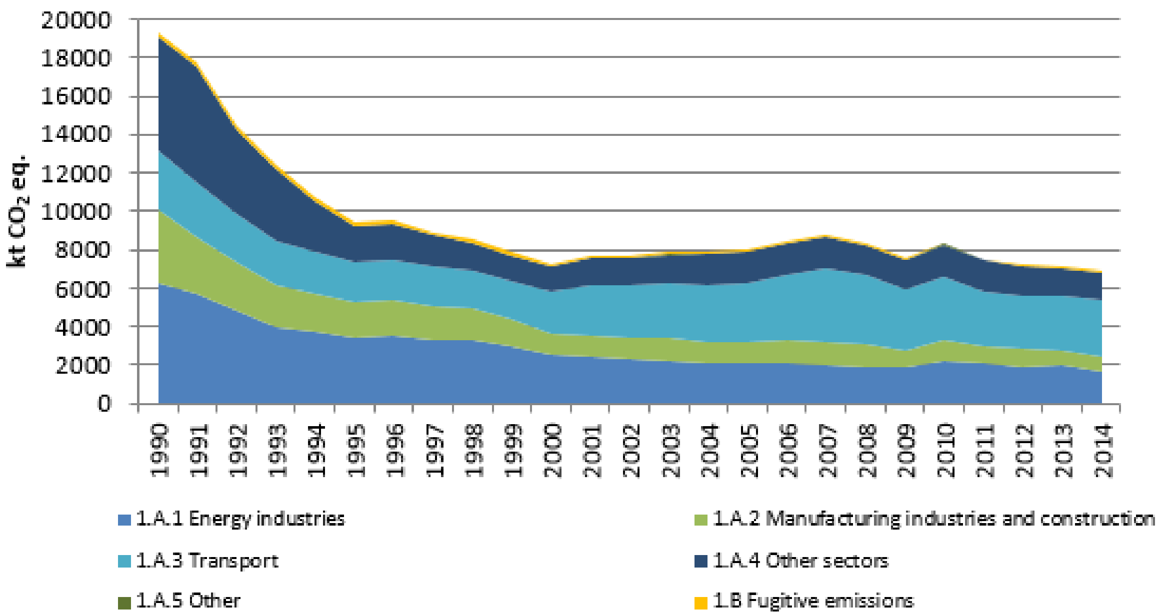


**Figure 3.3 GHG emissions from Energy sector 1990–2014 (kt $CO_2$ eq.)**

In CRF 1.A.1 Energy industries sector GHG emission decrease in 2008-2009 can be explained with the recession in national economy caused by global financial crisis, also the winter in 2009 was quite warm, therefore in 2009 GHG aggregated emissions in 1.A.1 were 2.6% less than in 2008, but in 2009-2010 an increase of emissions by 20.5% in Energy industries was observed, mostly because of the ending of the global crisis and also the average temperature in winter was lower than in year 2009. As year 2011 was warmer than previous year, the fuel consumption, as well as the emissions decreased by 7.9% if compared with year 2010. However, the average temperature in 2012 was less than in 2011, but the amounts of consumed energy resources continued to decrease as well as the emissions which decreased by 10.3% comparing to 2011. In 2013 emissions from Energy industries increased by 3.8%, if compared to 2012, but in 2014 emissions decreased by 13.1%.

The decrease of industrial production (CRF 1.A.2) was influenced by economic situation when development of national economy was made in financial and real estate sectors but the import dominated over export. Increase of costs and prices as well as total inflation led to a total decrease of local industry. Therefore GHG emissions from CRF 1.A.2 sector decreased by 19.9% in 2008-2009, but in 2010 emissions increased by 22.6% as fuel consumption increased. In year 2011 emissions decreased by 17.9% which can be explained with great reconstructions in the steel and iron enterprise "Liepājas Metalurgs" under 1.A.2.a sector where the fuel consumption decreased significantly. In 2012 in comparison to 2011 the GHG emissions increased by 5.3% mainly due to intensified steel melting in „Liepājas Metalurgs". However in 2013 decrease in 1.A.2. emissions by 16.7% can be observed, which is related to activities in "Liepājas Metalurgs". "Liepājas Metalurgs" went bankrupt in 2013. Emissions continue to decrease also in 2014 by 8.3 %.

For Transport sector (CRF 1.A.3) emissions decreased from 2008 to 2009 by 12.4% that was influenced by sharp increase of fuel price and economy crisis. Decrease is also explained with improvement of car park in country, where old cars were replaced with new ones. Starting from 2010 growth of emissions from transport sector is observed by 2.1% comparing to

2009, although in year 2011 the emissions decreased again and compared to 2010 the decrease was 11.0%. Decrease in emissions can be observed also in 2011-2012 by 3.5%, but in 2013 emissions had increased by 1.3%. In 2014 the increase in emissions has been 4.3%.

Emissions in CRF 1.A.4 Other sectors are constantly decreasing since 1990, with fluctuations in emissions in the time scale which mostly depend on the temperatures in winter. In 2013 in comparison to 2012 emissions had decreased by 3.1%, but in 2013-2014 GHG emissions increased by 0.2%.

The emissions in 1.A.5 Other have increased by 46.5% in 2013-2014, and it is not related to financial circumstances nor weather conditions.

Fluctuations of fugitive emissions can be explained with a constant improvement of natural gas supply infrastructure.

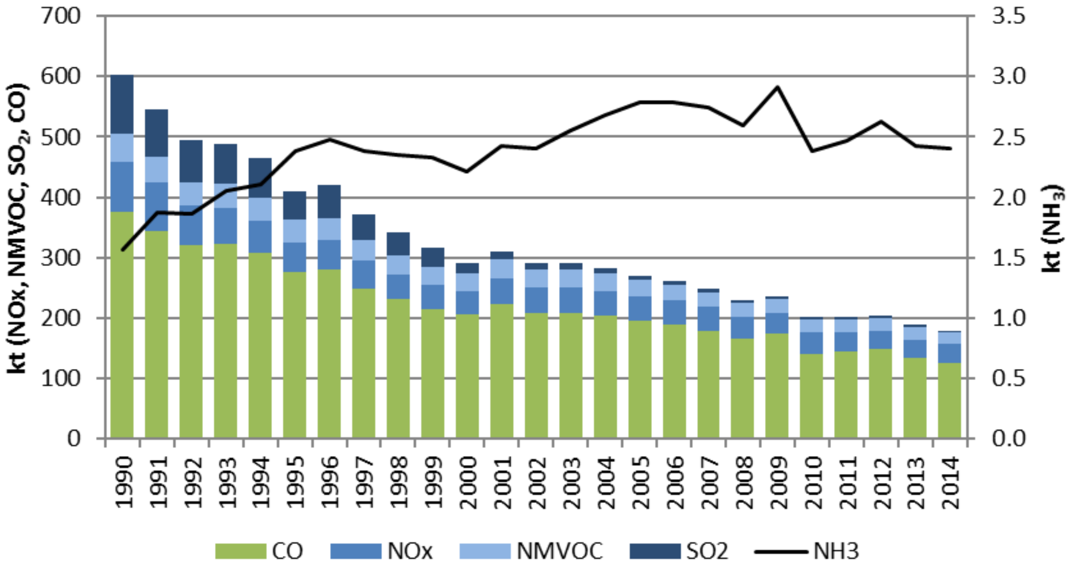


**Figure 3.4 Total indirect GHG emissions from Energy sector in 1990–2014 (kt)**

In 2014, the largest part of indirect emissions contributes CO then NMVOC and NOx emissions (Figure 3.4). Most CO and NMVOC emissions come from wood combustion in the Residential sector while the largest share of NOx emissions comes from Transport sector.

The biggest decrease is observed in $SO_2$ emissions where emissions decreased from 96.41 kt in 1990 to 3.61 kt in 2014. It is explained with changes in type of fuels combusted in Energy sector as well as with implementation of national legislations for sulphur content in liquid fuels used for transport.

The indirect emissions in general are lower in 2014 if compared to 2013: CO emissions have decreased by 5.6%, $NO_x$ emissions have decreased by 1.4%, and $SO_x$ emissions – by 1.0%, while NMVOCs have decreased by 3.2%. It can be explained mainly with smaller amounts of fuel combusted in Energy sector.

There are also ammonia emissions calculated and reported in Energy. According to EMEP/EEA 2013, ammonia emissions arise from biomass combustion and in Transport sector. In 1990-2014, $NH_3$ emissions have increased by 52.8% that can be explained with increased amounts of biomass burned in Manufacturing industries, as well as in Other (heat production in institutions, households, agriculture, forestry, fisheries).

### 3.1.2 Description

*Activity data*

Both the imported (natural gas, liquid gas, oil and oil products, coal) and local fuels (wood, peat, hydro resources) are used in the Energy sector in Latvia (Table 3.2). Mainly the imported fuels (natural gas, coal) are used in heat generation. Smaller boiler houses burn local fuel (wood) and coal as well.

**Table 3.2 Consumption of energy resources in Latvia (TJ)[13]**

| | 1990 | 1995 | 2000 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Energy consumption*** | ***318570*** | ***176159*** | ***143524*** | ***170096*** | ***174022*** | ***178707*** | ***183588*** | ***186027*** | ***179338*** | ***178015*** | ***185740*** | ***173188*** | ***175848*** | ***176162*** | ***175134*** |
| ***Liquid fuels, total[14]*** | *161209* | *81674* | *53518* | *63509* | *65802* | *68093* | *71073* | *75890* | *72810* | *70659* | *72127* | *64486* | *64456* | *64721* | *65592* |
| **Gasoline** | 26771 | 18130 | 14837 | 15225 | 15358 | 15138 | 16769 | 18307 | 16680 | 13945 | 12667 | 11926 | 10146 | 9286 | 9023 |
| **Diesel oil** | 48021 | 18274 | 20906 | 32230 | 34484 | 36791 | 39208 | 43862 | 41066 | 39141 | 42013 | 38520 | 38958 | 39433 | 40769 |
| **RFO** | 76326 | 41290 | 9462 | 9298 | 9013 | 10231 | 7634 | 6581 | 7795 | 10272 | 8661 | 6541 | 6942 | 6852 | 6821 |
| **LPG** | 3691 | 1548 | 2095 | 2323 | 2460 | 2552 | 2688 | 2414 | 2186 | 2003 | 2102 | 2414 | 3280 | 3840 | 4235 |
| **Jet fuel** | 3068 | 1171 | 1142 | 1728 | 2134 | 2525 | 2875 | 3438 | 4137 | 4320 | 4946 | 4943 | 5033 | 5209 | 4646 |
| **Other kerosene** | 647 | 432 | 43 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | 2684 | 749 | 2593 | 1435 | 1146 | 269 | 1155 | 1038 | 866 | 774 | 1072 | 64 | 58 | 100 | 97 |
| **Petroleum coke** | NO | NO | NO | 956 | 1088 | 429 | 627 | 132 | NO | 165 | 627 | NO | NO | NO | NO |
| **Shale oil** | NO | 78 | 2440 | 314 | 118 | 157 | 117 | 118 | 79 | 39 | 39 | 79 | 39 | NO | NO |
| ***Solid fuels, total*** | *26249* | *7225* | *2785* | *2674* | *2596* | *3199* | *3439* | *4248* | *4225* | *3409* | *4378* | *4509* | *3645* | *2905* | *2473* |
| **Coal** | 25984 | 7172 | 2759 | 2647 | 2569 | 3145 | 3407 | 4248 | 4225 | 3409 | 4378 | 4509 | 3563 | 2878 | 2473 |
| **Coke** | 237 | 53 | 26 | 27 | 27 | 54 | 32 | NO | NO | NO | NO | NO | NO | NO | NO |
| **Anthracite** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 82 | 27 | NO |
| **Oil shale** | 28 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| ***Peat products, total*** | *3216* | *3836* | *2392* | *673* | *80* | *80* | *70* | *90* | *51* | *26* | *46* | *43* | *34* | *64* | *35* |
| **Peat briquettes** | 867 | 401 | 31 | NO | NO | NO | NO | 1 | 1 | 6 | 6 | 3 | 4 | 4 | 5 |
| **Peat** | 2349 | 3435 | 2361 | 673 | 80 | 80 | 70 | 89 | 50 | 20 | 40 | 40 | 30 | 60 | 30 |
| ***Natural gas*** | *99517* | *41304* | *44962* | *55666* | *55247* | *56685* | *58627* | *56588* | *55478* | *50742* | *61044* | *53528* | *50301* | *49994* | *44798* |
| ***Biomass, total*** | *27501* | *42120* | *39774* | *46957* | *49574* | *49678* | *50032* | *48913* | *46372* | *53017* | *47647* | *49871* | *56535* | *57364* | *60958* |
| **Wood and wood products** | 27501 | 42102 | 39695 | 46670 | 49136 | 49120 | 49518 | 48402 | 45749 | 52291 | 45376 | 46594 | 52169 | 52676 | 55531 |
| **Bioethanol** | NO | NO | NO | NO | NO | NO | 43 | NO | 1 | 108 | 350 | 318 | 279 | 264 | 257 |
| **Biodiesel** | NO | NO | NO | NO | NO | 107 | 60 | 73 | 82 | 73 | 808 | 749 | 659 | 631 | 741 |
| **$CH_4$ from sludge gas** | NO | 18 | 41 | 43 | 78 | 90 | 76 | 80 | 79 | 100 | 114 | 100 | 105 | 97 | 91 |
| **$CH_4$ from landfill gas** | NO | NO | NO | 162 | 242 | 251 | 259 | 271 | 290 | 323 | 331 | 349 | 347 | 371 | 348 |
| **$CH_4$ from other biogas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 37 | 465 | 1629 | 2140 | 2535 |
| **Straws** | NO | NO | NO | NO | NO | NO | 11 | 16 | 14 | 29 | 60 | 43 | 38 | 58 | 99 |
| **Charcoal** | NO | NO | NO | NO | 30 | 60 | 30 | 45 | 60 | 60 | 60 | 60 | 59 | 90 | 90 |
| **Municipal** | NO | NO | 37 | 82 | 89 | 49 | 34 | 26 | 98 | 33 | 510 | 1193 | 1250 | 1035 | 1266 |

*[13] Excluding electricity.*

*[14] Including fuel consumption for international aviation and international navigation.*

| | 1990 | 1995 | 2000 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| wastes (biomass fraction) | | | | | | | | | | | | | | | |
| *Other fuels, total* | *879* | *NO* | *94* | *617* | *722* | *972* | *348* | *299* | *401* | *162* | *499* | *752* | *877* | *1115* | *1279* |
| Industrial wastes (used tires) | NO | NO | 94 | 208 | 224 | 125 | 85 | 65 | 58 | 15 | 84 | 331 | 242 | 379 | 335 |
| Municipal wastes | NO | NO | NO | NO | NO | NO | NO | NO | 80 | 30 | 320 | 332 | 577 | 707 | 915 |
| Waste oils | 879 | NO | NO | 409 | 498 | 847 | 263 | 234 | 263 | 117 | 95 | 88 | 58 | 29 | 29 |

*Liquid fossil fuels* have an important place in the Latvian energy resource market; their market share is about 37% in 2014, including residual fuel oil. The share of residual fuel oil consumption has a significant decrease - in 1990 it was 24% from total fuel consumption, but in 2014 it is 3.9%. The essential decrease of heavy oil share in energy balance is explained with increase of costs due to increasing fuel costs because of implementation of the EU Directive 1999/32/EC prescribing that sulphur content of heavy oil shall not exceed 1%. The biggest part from liquid fuel consumption contributes to gasoline and diesel oil with approximately 75.9% from total liquid fuel consumption in 2014 where gasoline is mostly consumed in transport sector and only a small part is used in off-roads. Diesel oil consumption divides by combusted in transport sector – 76.2%, and combusted in stationary combustion installations – 23.8% from total diesel oil consumption in 2014. The total consumption of liquid fuels in 2014 has decreased by 59.3% since 1990.

Total share of *solid fuels* in national market is quite low – approximately 1.4% in 2014. The solid fuel consumption in recent years is stable although the consumption have decreased by 90.6% since 1990. A decrease in solid fuel consumption (-19.3%) can be seen in 2008-2009 due to global economic crisis. However, from 2009 to 2011 it increased by 32.3% that can mainly be explained with an increase of coal consumption, but in years 2011-2014 there can be seen a decrease in solid fuel consumption by 45.2% due to reduced use of coal.

*Peat* and *peat briquettes* are local fuels quite widely used in Latvia in 1990 with 1.0% of total energy consumption. However, nowadays amounts of peat products used have decreased and have reached 0.02% of total share in 2014.

The largest consumers of *natural gas* are combined heat and power plant, and heat generation enterprises as well as industrial enterprises. Natural gas has a stable place in total fuel consumption where its share is 31.2% in 1990 and 25.6% in 2014. Natural gas consumption has decreased by 55.0% in 1990-2014. Recent years until 2011 the consumption of natural gas had an increasing trend – from 2009 to 2010 it increased by 20.3%, but in 2010-2014 there can be seen a decrease of natural gas consumption by 26.6%.

*Biomass* fuels are wood and wood products, straw, charcoal and liquid biofuels – bioethanol and biodiesel. In the total fuel consumption the share of firewood and other wood products is quite substantial and has reached its peak with 31.7% of total energy consumption in 2014, comparing with 1990 when firewood consumption was only about 8.6% from total energy consumption. In 2010-2014 wood and wood products' use increased by 22.4%. In latest years liquid and gaseous biofuels are becoming more popular and their share from 0.25% in 2005 has reached 2.27% in 2014 from total fuel consumption. Recently also such biomass fuels as straws are used, and it has an increasing trend with fluctuations, especially in 2010-2011 and 2013-2014, which can mainly be explained with significant temperature differences in winter.

There are also *industrial* and *municipal waste*[15] consumed in the latest years, and the most significant increase can be observed in 2010 – comparing with 2009 the consumption of waste has almost 12-fold increase, and it reached 0.49% from total share. However, in the following years the increase of other fuels consumed was not as rapid as in previous 2009-2010, and the increase in particular fuels' use in 2013-2014 was by 19%, and the share of total was 1.44% in 2014. Also used oils are reported as other fuels, however, this fuel type has a decreasing trend.

Hydroelectric power plants (HPP) and combined heat and power plants (CHP) produce part of the electrical power, while part is imported (Table 3.3, Table 3.4). Volume of electricity generation directly depends on the through-flow of the river Daugava. Also the import of electricity from Russia, Estonia and Lithuania has a quite substantial role in the electricity supply.

**Table 3.3 Heat production and consumption in Latvia (TJ)**

| | Production | Own use and losses | Final consumption | | |
|---|---|---|---|---|---|
| | | | CRF 1.A.2 | CRF 1.A.4 | TOTAL |
| **1990** | 99439 | 15171 | 32929 | 51339 | 84268 |
| **1995** | 46112 | 7156 | 1969 | 36987 | 38956 |
| **2000** | 31867 | 6815 | 659 | 24393 | 25052 |
| **2001** | 33937 | 7038 | 641 | 26258 | 26899 |
| **2002** | 33048 | 6541 | 630 | 25877 | 26507 |
| **2003** | 33516 | 6409 | 626 | 26481 | 27107 |
| **2004** | 31093 | 6174 | 608 | 24311 | 24919 |
| **2005** | 31144 | 5886 | 684 | 24574 | 25258 |
| **2006** | 30056 | 5454 | 634 | 23968 | 24602 |
| **2007** | 28685 | 4911 | 554 | 23220 | 23774 |
| **2008** | 26402 | 4010 | 356 | 22036 | 22392 |
| **2009** | 26308 | 4099 | 298 | 21911 | 22209 |
| **2010** | 28662 | 4590 | 387 | 23685 | 24072 |
| **2011** | 25000 | 4104 | 268 | 20628 | 20896 |
| **2012** | 26857 | 4464 | 259 | 22134 | 22393 |
| **2013** | 26249 | 4551 | 479 | 21219 | 21698 |
| **2014** | 25747 | 4608 | 890 | 20249 | 21139 |

**Table 3.4 Electricity production and consumption in Latvia (TJ)**

| | Production | Own use and losses | Import | Export | Final consumption | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | CRF 1.A.2 | CRF 1.A.3 | CRF 1.A.4 | TOTAL |
| 1990 | 23933 | 6883 | 25700 | 12798 | 11484 | 918 | 17550 | 29952 |
| 1991 | 20318 | 6682 | 15217 | 7 | 10807 | 785 | 17255 | 28847 |
| 1992 | 13803 | 5645 | 14688 | 7 | 8316 | 745 | 13777 | 22838 |
| 1993 | 14126 | 6102 | 9619 | 612 | 5440 | 688 | 10904 | 17032 |
| 1994 | 15984 | 6681 | 9533 | 2988 | 5076 | 670 | 10102 | 15848 |

[15] *For reporting purposes municipal waste has been divided into fossil and non-fossil fractions, but in the particular paragraph it is described as whole.*

| | Production | Own use and losses | Import | Export | Final consumption | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | CRF 1.A.2 | CRF 1.A.3 | CRF 1.A.4 | TOTAL |
| 1995 | 14324 | 6372 | 9529 | 1408 | 5130 | 677 | 10267 | 16074 |
| 1996 | 11254 | 7989 | 12377 | 760 | 4975 | 641 | 9266 | 14882 |
| 1997 | 16218 | 7694 | 6566 | 4 | 5519 | 634 | 8935 | 15088 |
| 1998 | 20869 | 6559 | 3290 | 1382 | 5296 | 612 | 10310 | 16218 |
| 1999 | 14796 | 5774 | 9349 | 2311 | 5130 | 554 | 10375 | 16059 |
| 2000 | 14890 | 5202 | 7589 | 1159 | 5159 | 547 | 10411 | 16117 |
| 2001 | 15408 | 5688 | 8424 | 1645 | 5562 | 623 | 10314 | 16499 |
| 2002 | 14310 | 5188 | 10217 | 1764 | 5494 | 518 | 11563 | 17575 |
| 2003 | 14310 | 5065 | 9616 | 137 | 5778 | 490 | 12456 | 18724 |
| 2004 | 16881 | 4975 | 9839 | 2290 | 5882 | 500 | 13072 | 19454 |
| 2005 | 17658 | 4767 | 10278 | 2545 | 6120 | 533 | 13972 | 20625 |
| 2006 | 17607 | 4522 | 10116 | 1087 | 6332 | 540 | 15242 | 22114 |
| 2007 | 17176 | 4194 | 17870 | 7070 | 6538 | 504 | 16740 | 23782 |
| 2008 | 18987 | 4198 | 16715 | 7643 | 6066 | 497 | 17298 | 23861 |
| 2009 | 20048 | 4032 | 15333 | 9378 | 5421 | 436 | 16114 | 21971 |
| 2010 | 23857 | 4626 | 14303 | 11160 | 5724 | 453 | 16197 | 22374 |
| 2011 | 21938 | 4133 | 14432 | 9950 | 6012 | 446 | 15829 | 22287 |
| 2012 | 22202 | 3636 | 17766 | 11678 | 7175 | 464 | 17015 | 24654 |
| 2013 | 22352 | 3556 | 18018 | 13140 | 6509 | 446 | 16719 | 23674 |
| 2014 | 18508 | 3146 | 19221 | 10883 | 6003 | 421 | 17276 | 23700 |

Types of fuels used for combustion in Latvia:

**Liquid fuels** are mainly imported from Latvia's neighbouring countries – Lithuania, Belarus, Russian Federation, Norway and others and consist of:

- shale oil;
- liquefied petroleum gas;
- motor gasoline and aviation gasoline;
- kerosene type jet fuel;
- other kerosene;
- gasoline type jet fuel;
- motor diesel oil and heating gas oil;
- residual fuel oil (RFO);
- other liquids;
- petroleum coke.

**Solid fuels** consist of coal and coke imported from Commonwealth of Independent States (countries of former Union of Soviet Socialist Republics), as well as local fuel – peat briquettes – that are mainly produced inside country but not imported;

**Peat** is 100% produced inside of the country;

**Gaseous fuels** (natural gas) are 100% imported from Russian Federation;

**Biomass fuels**:

- solid biomass – wood and other wood products, charcoal, straw, is mainly produced and used inside of the country,

- methane obtained from biogas that is 100% produced inside of the country – landfill gas that is used since 2002 when first landfill started to collect and combust biogas with energy recovery, and sludge gas that is combusted with energy recovery since 1993 in one sewage purification plant, and also other biogases from anaerobic fermentation,
- liquid biofuels – biogasoline and biodiesel, which are mainly imported from Latvia's neighbourhood countries.

**Other fuels** are municipal waste (ecofuel) and industrial waste – used tires, different types of industrial ecofuel collected by and combusted in cement production plant in Latvia, as well as used oils.

*Methodological issues*

**Table 3.5 Methods and emission factors used in Energy sector**

| | $CO_2$ | | $CH_4$ | | $N_2O$ | |
|---|---|---|---|---|---|---|
| **CATEGORIES** | **Method applied** | **Emission factor** | **Method applied** | **Emission factor** | **Method applied** | **Emission factor** |
| **1. Energy** | T1, T2, T3 | CS, D, OTH, PS | T1, T2 | CR, CS, D, OTH | T1, T2 | CR, D, OTH |
| A. Fuel combustion | T1, T2, T3 | CS, D, OTH, PS | T1, T2 | CR, CS, D, OTH | T1, T2 | CR, D, OTH |
| 1. Energy industries | T1, T2 | CS, D | T1 | D | T1 | D |
| 2. Manufacturing industries and construction | T1, T2, T3 | CS, D, PS | T1 | D | T1 | D |
| 3. Transport | T1, T2 | CS, D, OTH | T1, T2 | CR, D, OTH | T1, T2 | CR, D, OTH |
| 4. Other sectors | T1, T2 | CS, D | T1, T2 | CS, D | T1 | D |
| 5. Other | T1 | D | T1 | D | T1 | D |
| B. Fugitive emissions from fuels | T2 | CS | T2 | CS | *NA, NO* | *NA, NO* |
| 1. Solid fuels | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* |
| 2. Oil and natural gas | T2 | CS | T2 | CS | *NA* | *NA* |
| C. $CO_2$ transport and storage | *NO* | *NO* | *NO* | *NO* | *NO* | *NO* |

The main methods and emission factors can be seen on Table 3.5. It can be seen that in fuel combustion for $CO_2$ emission calculations there are methods from Tier 1 to Tier 3 used, generally Tier 2, while for $CH_4$ and $N_2O$ Tier 1 and Tier 2 are used, generally Tier 1. In stationary combustion, $CO_2$ emission factors are country-specific (CS), but for $CH_4$ and $N_2O$ – default values (D) from 2006 IPCC Guidelines, while in transport country-specific, default, Corinair (CR) and other (OTH) values are used. For fugitive emissions, Tier 2 method and country-specific emission factors are used. As there are no GHG emissions from solid fuels, but there are particulate matter emissions reported, there can be seen a notation key "NA", while for $CO_2$ transport and storage there are no operations, therefore "NO" is used.

*Key categories*

Key categories of Energy sector are presented in Table 3.6. Key categories are estimated using Approach 1 and Approach 2 both by level and trend with and without taking LULUCF sector into account.

**Table 3.6 Key categories in Energy sector in 2014**

| IPCC category/Group | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | T1 | X | X |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | L1,T1 | | X |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | T1 | | X |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | T1 | X | X |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | T1 | | X |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | T1 | | X |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | T1 | X | X |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | L1,T1 | X | X |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | L1,T1 | X | X |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | L1 | X | X |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | T2 | | X |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | T2 | | X |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | L1,L2,T1 | X | X |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | L1,T1 | X | X |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | L2 | | X |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | L1,L2,T2 | | X |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | L1,L2,T1 | X | X |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | T1 | | X |

| IPCC category/Group | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | L1,L2,T1,T2 | X | X |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | L1,L2,T1 | X | X |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | L1,T1,T2 | X | X |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | T2 | | X |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | L1,L2,T1,T2 | X | X |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | L1,L2,T1 | X | X |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | L1,L2,T1,T2 | | X |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | T1,T2 | X | X |
| 1.B.2.b Natural Gas | $CH_4$ | L1,L2,T1,T2 | X | X |
| 1.B.2.c Venting and Flaring | $CH_4$ | L1 | | X |

## *3.2 FUEL COMBUSTION (CRF 1.A)*

Emissions from fuel combustion comprise all in-country fuel combustion, including point sources, transport and other fuel combustion. Emissions from fuel combustion in the Energy sector are divided into following subcategories:

- 1.A.1 Energy Industries;
- 1.A.2 Manufacturing Industries and Construction;
- 1.A.3 Transport – road transport, civil aviation, railways and domestic navigation;
- 1.A.4 Other Sectors (Commercial/Institutional, Residential, Agriculture/Forestry/Fisheries);
- 1. A.5 Other (Not elsewhere specified) – military transport.

Reported greenhouse gas emissions are listed in Table 3.7.

**Table 3.7 Reported emissions from fuel combustion in Latvia in 2014**

| Source | Fuel Type | Emissions | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ |
| 1.A.1 Energy Industries | | | | | | | | |
| a. Public Electricity and Heat Production | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Peat | √ | √ | √ | √ | √ | √ | √ |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| b. Petroleum Refining | | | | | | | | |
| | Liquid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Solid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Biomass | NO | NO | NO | NO | NO | NO | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |

| Source | Fuel Type | Emissions | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ |
| c. Manufacture of Solid Fuels and Other Energy Industries | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | NO | NO | NO | NO | NO | NO | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| 1.A.2 Manufacturing Industries and Construction | | | | | | | | |
| a. Iron and Steel | | | | | | | | |
| | Liquid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Solid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | NO | NO | NO | NO | NO | NO | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| b. Non-Ferrous Metals | | | | | | | | |
| | Liquid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Solid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | NO | NO | NO | NO | NO | NO | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| c. Chemicals | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Peat | √ | √ | √ | √ | √ | √ | √ |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| d. Pulp, Paper and Print | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| e. Food Processing, Beverages and Tobacco | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| f. Non-metallic minerals | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | NO |
| | Other Fuels | √ | √ | √ | √ | √ | √ | √ |
| g. Other | | | | | | | | |

| Source | Fuel Type | Emissions | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Peat | √ | √ | √ | √ | √ | √ | √ |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| 1.A.3 Transport | | | | | | | | |
| a. Civil Aviation | | | | | | | | |
| | Aviation Gasoline | √ | √ | √ | √ | √ | √ | √ |
| | Jet Kerosene | √ | √ | √ | √ | √ | √ | √ |
| b. Road Transportation | | | | | | | | |
| | Gasoline | √ | √ | √ | √ | √ | √ | √ |
| | Diesel Oil | √ | √ | √ | √ | √ | √ | √ |
| | LPG | √ | √ | √ | √ | √ | √ | √ |
| | Other Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Gaseous Fuels | NA | NA | NA | NA | NA | NA | NA |
| | Biomass | √ | √ | √ | NO | NO | NO | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| c. Railways | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | √ |
| | Other Fuels | NA | NA | NA | NA | NA | NA | NA |
| d. Navigation | | | | | | | | |
| | Residual Oil (Residual Fuel Oil) | NO | NO | NO | NO | NO | NO | NO |
| | Gas/Diesel Oil | √ | √ | √ | √ | √ | √ | √ |
| | Gasoline | √ | √ | √ | √ | √ | √ | √ |
| | Other Liquid Fuels | NA | NA | NA | NA | NA | NA | NA |
| | Gaseous Fuels | NA | NA | NA | NA | NA | NA | NA |
| | Biomass | NO | NO | NO | NO | NO | NO | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| e. Other Transportation | | | | | | | | |
| | Liquid Fuels | IE | IE | IE | IE | IE | IE | IE |
| | Solid Fuels | IE | IE | IE | IE | IE | IE | IE |
| | Gaseous Fuels | IE | IE | IE | IE | IE | IE | IE |
| | Biomass | IE | IE | IE | IE | IE | IE | IE |
| | Other Fuels | IE | IE | IE | IE | IE | IE | IE |
| 1.A.4 Other Sectors | | | | | | | | |
| a. Commercial/Institutional | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| b. Residential | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Peat | NO | NO | NO | NO | NO | NO | NO |

| Source | Fuel Type | Emissions | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| c. Agriculture/Forestry/Fisheries | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | √ | √ | √ | √ | √ | √ | NO |
| | Biomass | √ | √ | √ | √ | √ | √ | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| 1.A.5 Other | | | | | | | | |
| a. Stationary | | | | | | | | |
| | Liquid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Solid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Biomass | NO | NO | NO | NO | NO | NO | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |
| b. Mobile – Military navigation and aircrafts | | | | | | | | |
| | Liquid Fuels | √ | √ | √ | √ | √ | √ | √ |
| | Solid Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Peat | NO | NO | NO | NO | NO | NO | NO |
| | Gaseous Fuels | NO | NO | NO | NO | NO | NO | NO |
| | Biomass | NO | NO | NO | NO | NO | NO | NO |
| | Other Fuels | NO | NO | NO | NO | NO | NO | NO |

$CO_2$ emissions from fuel combustion were 6499.67 kt (including Transport sector) in 2014 and accounted for 91.0% of the total $CO_2$ emissions.

$CH_4$ emissions from fuel combustion were 7.02 kt (including Transport sector) in 2014 and accounted for 8.4% of total $CH_4$ emissions. The biggest part of $CH_4$ emissions contributes to Other sectors (CRF 1.A.4) – 5.89 kt.

$N_2O$ emissions from fuel combustion were 0.48 kt (including Transport sector) and accounted 7.5% of the total $N_2O$ emissions in 2014.

### 3.2.1 Comparison of the sectoral approach with the reference approach (CRF 1.A (b), 1.A(c))

Reference approach (RA) is carried out using import, export, production and stock change data as well as data of fuel consumption in international aviation and international marine reported as bunkering from the CSB online database where Energy balance is available.

Difference between fuel consumption estimated with RA and SA for liquid fuels is quite high – from 3.54% in 1995 to -18.77% in 2010 (Table 3.8). Difference for solid fuels is smaller from 0.60% in 1992 to -0.01% in 1995 and 2014. Difference for gaseous fuels fluctuates from 3.10% in 1993 to 0.14% in 1990. For other fuels the fluctuations are from 1.2% in 2014 to -0.14% in 2004. For peat the fluctuations are more remarkable – from 130.43% in 2010 to 0% in 2002, 2011 and 2012.

**Table 3.8 Difference (%) between Sectoral and Reference approach data (PJ) and $CO_2$ emissions (kt)**

| | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fuel consumption - Liquid fuels** | | | | | | | | | | | |
| **SA** | 138.39 | 123.94 | 103.92 | 96.87 | 91.09 | 74.33 | 80.21 | 68.90 | 67.76 | 63.13 | 52.05 |
| **RA** | 139.69 | 123.02 | 104.06 | 96.47 | 93.03 | 76.96 | 78.52 | 67.31 | 66.34 | 55.09 | 44.94 |
| **Diff., %** | 0.94 | -0.75 | 0.13 | -0.41 | 2.13 | 3.54 | -2.11 | -2.30 | -2.10 | -12.74 | -13.66 |
| **$CO_2$ emissions - Liquid fuels** | | | | | | | | | | | |
| **SA** | 10272.41 | 9184.73 | 7702.74 | 7181.04 | 6781.17 | 5523.57 | 5977.26 | 5111.69 | 5020.72 | 4670.44 | 3814.53 |
| **RA** | 10437.39 | 9140.65 | 7732.14 | 7183.80 | 6953.17 | 5747.36 | 5883.10 | 5022.08 | 4958.06 | 4151.16 | 3342.76 |
| **Diff., %** | 1.61 | -0.48 | 0.38 | 0.04 | 2.54 | 4.05 | -1.58 | -1.75 | -1.25 | -11.12 | -12.37 |
| **Fuel consumption - Solid fuels** | | | | | | | | | | | |
| **SA** | 26.25 | 22.51 | 18.76 | 17.09 | 12.17 | 7.22 | 6.85 | 5.63 | 4.18 | 3.64 | 2.79 |
| **RA** | 26.36 | 22.63 | 18.87 | 17.15 | 12.17 | 7.22 | 6.86 | 5.63 | 4.18 | 3.64 | 2.79 |
| **Diff., %** | 0.44 | 0.51 | 0.60 | 0.36 | 0.01 | -0.01 | 0.03 | 0.01 | 0.08 | 0.05 | 0.06 |
| **$CO_2$ emissions - Solid fuels** | | | | | | | | | | | |
| **SA** | 2486.39 | 2129.65 | 1774.29 | 1618.24 | 1152.55 | 684.11 | 648.95 | 533.22 | 395.54 | 344.65 | 263.81 |
| **RA** | 2502.91 | 2151.66 | 1799.14 | 1635.33 | 1172.45 | 700.97 | 666.06 | 561.51 | 424.11 | 373.07 | 292.24 |
| **Diff., %** | 0.66 | 1.03 | 1.40 | 1.06 | 1.73 | 2.46 | 2.64 | 5.31 | 7.22 | 8.25 | 10.78 |
| **Fuel consumption - Gaseous fuels** | | | | | | | | | | | |
| **SA** | 99.52 | 98.84 | 70.75 | 46.15 | 33.62 | 41.30 | 35.22 | 43.12 | 42.22 | 40.44 | 44.96 |
| **RA** | 99.65 | 100.47 | 72.23 | 47.58 | 34.62 | 42.28 | 36.22 | 44.15 | 43.25 | 41.44 | 45.74 |
| **Diff., %** | 0.14 | 1.64 | 2.09 | 3.10 | 2.98 | 2.36 | 2.84 | 2.39 | 2.44 | 2.47 | 1.72 |
| **$CO_2$ emissions - Gaseous fuels** | | | | | | | | | | | |
| **SA** | 5458.95 | 5421.63 | 3952.80 | 2578.92 | 1863.43 | 2285.06 | 1965.95 | 2404.37 | 2357.14 | 2252.13 | 2490.55 |
| **RA** | 5469.25 | 5513.98 | 4038.03 | 2660.67 | 1920.09 | 2340.56 | 2023.08 | 2463.47 | 2416.34 | 2309.25 | 2535.05 |
| **Diff., %** | 0.19 | 1.70 | 2.16 | 3.17 | 3.04 | 2.43 | 2.91 | 2.46 | 2.51 | 2.54 | 1.79 |
| **Fuel consumption - Peat** | | | | | | | | | | | |
| **SA** | 3.22 | 3.24 | 3.85 | 3.62 | 3.37 | 3.84 | 3.50 | 3.47 | 2.45 | 1.36 | 2.39 |
| **RA** | 3.29 | 3.27 | 3.86 | 3.66 | 3.37 | 3.84 | 3.50 | 3.47 | 2.46 | 1.37 | 2.45 |
| **Diff., %** | 2.21 | 0.68 | 0.26 | 0.86 | 0.02 | 0.07 | 0.05 | 0.08 | 0.45 | 0.71 | 2.52 |
| **$CO_2$ emissions - Peat** | | | | | | | | | | | |
| **SA** | 328.50 | 333.01 | 395.57 | 372.95 | 347.99 | 395.92 | 360.29 | 357.78 | 252.88 | 140.49 | 248.21 |
| **RA** | 337.34 | 336.22 | 397.72 | 376.89 | 348.52 | 396.74 | 361.06 | 358.52 | 254.32 | 141.62 | 254.67 |
| **Diff., %** | 2.69 | 0.96 | 0.55 | 1.06 | 0.15 | 0.21 | 0.21 | 0.21 | 0.57 | 0.80 | 2.60 |
| **Fuel consumption - Other fuels** | | | | | | | | | | | |
| **SA** | 0.88 | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | 0.03 | 0.09 |
| **RA** | 0.88 | NO | NO | NO | NO | NO | NO | NO | NO | 0.03 | 0.09 |
| **Diff., %** | 0.00 | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | 0.00 | 0.00 |
| **$CO_2$ emissions - Other fuels** | | | | | | | | | | | |
| **SA** | 64.43 | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | 2.09 | 7.46 |
| **RA** | 64.46 | NO | NO | NO | NO | NO | NO | NO | NO | 1.56 | 5.58 |
| **Diff., %** | 0.05 | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | IE,NO | -25.30 | -25.30 |

## Continuation of Table 3.8

| | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fuel consumption - Liquid fuels** | | | | | | | | | | | | | | |
| **SA** | 52.28 | 52.07 | 53.97 | 55.31 | 54.74 | 60.06 | 65.06 | 60.14 | 54.94 | 56.70 | 50.59 | 49.40 | 49.77 | 51.30 |
| **RA** | 47.95 | 44.00 | 48.78 | 50.81 | 49.68 | 54.15 | 59.47 | 55.70 | 47.02 | 46.06 | 43.76 | 47.37 | 43.94 | 48.14 |
| **Diff., %** | -8.28 | -15.50 | -9.62 | -8.13 | -9.25 | -9.85 | -8.59 | -7.37 | -14.42 | -18.77 | -13.49 | -4.11 | -11.72 | -6.16 |
| **$CO_2$ emissions - Liquid fuels** | | | | | | | | | | | | | | |
| **SA** | 3818.74 | 3807.08 | 3958.28 | 4055.69 | 3997.20 | 4386.09 | 4741.54 | 4380.09 | 4010.00 | 4152.26 | 3683.99 | 3590.57 | 3613.00 | 3721.72 |
| **RA** | 3551.95 | 3259.55 | 3621.81 | 3752.90 | 3649.40 | 4008.04 | 4383.09 | 4105.11 | 3457.54 | 3414.85 | 3234.14 | 3504.74 | 3252.58 | 3515.40 |
| **Diff., %** | -6.99 | -14.38 | -8.50 | -7.47 | -8.70 | -8.62 | -7.56 | -6.28 | -13.78 | -17.76 | -12.21 | -2.39 | -9.98 | -5.54 |
| **Fuel consumption - Solid fuels** | | | | | | | | | | | | | | |
| **SA** | 3.64 | 2.93 | 2.67 | 2.60 | 3.20 | 3.44 | 4.25 | 4.23 | 3.41 | 4.38 | 4.51 | 3.65 | 2.91 | 2.47 |

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RA** | 3.64 | 2.93 | 2.68 | 2.60 | 3.20 | 3.44 | 4.25 | 4.25 | 3.41 | 4.38 | 4.51 | 3.65 | 2.91 | 2.47 |
| **Diff., %** | 0.06 | 0.06 | 0.04 | 0.04 | 0.04 | 0.03 | 0.00 | 0.54 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | -0.01 |
| **$CO_2$ emissions - Solid fuels** | | | | | | | | | | | | | | |
| **SA** | 344.46 | 277.36 | 253.28 | 245.91 | 303.26 | 325.71 | 401.85 | 399.71 | 322.48 | 414.17 | 426.54 | 345.12 | 274.91 | 233.95 |
| **RA** | 372.93 | 303.32 | 267.74 | 263.25 | 317.73 | 339.63 | 413.32 | 416.21 | 336.84 | 422.72 | 435.12 | 362.36 | 280.58 | 233.95 |
| **Diff., %** | 8.27 | 9.36 | 5.71 | 7.05 | 4.77 | 4.27 | 2.85 | 4.13 | 4.45 | 2.07 | 2.01 | 4.99 | 2.06 | 0.00 |
| **Fuel consumption - Gaseous fuels** | | | | | | | | | | | | | | |
| **SA** | 52.25 | 53.50 | 55.67 | 55.25 | 56.69 | 58.63 | 56.59 | 55.48 | 50.74 | 61.04 | 53.53 | 50.30 | 49.99 | 44.80 |
| **RA** | 53.16 | 54.07 | 56.41 | 55.79 | 56.85 | 58.89 | 56.92 | 55.81 | 51.38 | 61.31 | 54.03 | 50.81 | 50.54 | 45.39 |
| **Diff., %** | 1.74 | 1.07 | 1.33 | 0.97 | 0.29 | 0.45 | 0.59 | 0.61 | 1.26 | 0.44 | 0.95 | 1.00 | 1.10 | 1.31 |
| **$CO_2$ emissions - Gaseous fuels** | | | | | | | | | | | | | | |
| **SA** | 2889.47 | 2960.08 | 3075.07 | 3055.18 | 3133.27 | 3242.42 | 3129.73 | 3066.38 | 2807.04 | 3372.02 | 2956.18 | 2772.75 | 2710.99 | 2430.72 |
| **RA** | 2941.45 | 2993.55 | 3118.03 | 3086.86 | 3144.49 | 3259.24 | 3150.21 | 3087.00 | 2844.35 | 3389.23 | 2986.19 | 2802.53 | 2742.72 | 2464.34 |
| **Diff., %** | 1.80 | 1.13 | 1.40 | 1.04 | 0.36 | 0.52 | 0.65 | 0.67 | 1.33 | 0.51 | 1.02 | 1.07 | 1.17 | 1.38 |
| **Fuel consumption - Peat** | | | | | | | | | | | | | | |
| **SA** | 1.25 | 1.01 | 0.67 | 0.08 | 0.08 | 0.07 | 0.09 | 0.05 | 0.03 | 0.05 | 0.04 | 0.03 | 0.06 | 0.03 |
| **RA** | 1.25 | 1.01 | 0.91 | 0.09 | 0.08 | 0.07 | 0.09 | 0.09 | 0.04 | 0.11 | 0.04 | 0.03 | 0.08 | 0.04 |
| **Diff., %** | 0.06 | 0.00 | 35.80 | 13.75 | 1.12 | 1.14 | 0.83 | 78.08 | 38.46 | 130.43 | 0.00 | 0.00 | 31.25 | 0.42 |
| **CO2 emissions - Peat** | | | | | | | | | | | | | | |
| **SA** | 129.24 | 104.39 | 69.91 | 8.31 | 8.32 | 7.29 | 9.37 | 5.30 | 2.66 | 4.74 | 4.45 | 3.51 | 6.62 | 3.59 |
| **RA** | 129.41 | 104.46 | 95.00 | 9.46 | 8.42 | 7.38 | 9.45 | 9.45 | 3.70 | 10.98 | 4.45 | 3.51 | 8.73 | 3.60 |
| **Diff., %** | 0.13 | 0.07 | 35.89 | 13.83 | 1.19 | 1.21 | 0.90 | 78.30 | 39.13 | 131.66 | 0.08 | 0.08 | 31.85 | 0.20 |
| **Fuel consumption - Other fuels** | | | | | | | | | | | | | | |
| **SA** | 0.55 | 1.03 | 0.62 | 0.72 | 0.97 | 0.35 | 0.30 | 0.40 | 0.16 | 0.50 | 0.75 | 0.88 | 1.12 | 1.28 |
| **RA** | 0.55 | 1.03 | 0.62 | 0.72 | 0.97 | 0.35 | 0.30 | 0.40 | 0.16 | 0.50 | 0.75 | 0.88 | 1.12 | 1.29 |
| **Diff., %** | 0.00 | 0.00 | 0.00 | -0.14 | 0.10 | 0.00 | 0.00 | 0.00 | -0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 1.20 |
| **$CO_2$ emissions - Other fuels** | | | | | | | | | | | | | | |
| **SA** | 41.60 | 77.25 | 46.48 | 54.30 | 72.00 | 26.07 | 22.30 | 31.05 | 12.41 | 40.77 | 72.70 | 79.71 | 94.63 | 109.70 |
| **RA** | 38.08 | 72.49 | 42.32 | 49.74 | 69.30 | 24.16 | 20.85 | 26.37 | 10.80 | 22.40 | 34.68 | 36.28 | 59.71 | 58.75 |
| **Diff., %** | -8.46 | -6.15 | -8.95 | -8.40 | -3.76 | -7.33 | -6.50 | -15.08 | -13.04 | -45.07 | -52.30 | -54.48 | -36.90 | -46.44 |

The biomass consumption in the comparison is not included as this type of fuel is assumed as $CO_2$ neutral and $CO_2$ emissions from biomass combustion are taken into account in the $CO_2$ emission estimation from Energy sector.

Amount of used tires combusted in cement production plant is reported as Other fuels as well as municipal waste combusted in the same cement production plant. According to 2006 IPCC Guidelines, used oils are also reported under Other fuels.

#### 3.2.1.1 Explanation of the difference

*Energy balance*

In the Annual questionnaires, as well as in CSB online database statistical differences, distribution losses and interproduct transfer are reported for certain fuels, whereas in the Reference Approach (RA) table only stock changes are possible to insert. These data are not taken into account and are not put in stock changes' cells of the CRF Reporter RA tables. Therefore the difference in liquid fuels and peat have been quite significant for many years. For example, distribution losses for peat are quite visible, in comparison with total consumption, especially in 2010. To improve the transparency of reporting, the statistical differences, distribution losses, as well as interproduct transfers for the whole time series are presented in Annex A.3.1 of this report.

CSB estimates total consumption data by taking production, import, export, international bunkering and stock changes data into account. Final consumption data is estimated by taking into account sectoral consumption data reported by fuel consumers excluding reported distribution losses data. Transformation and Energy sectors are not included in final consumption data. For several fuel types difference between these two estimation approaches is reported as statistical difference that is quite significant for some fuel types – diesel oil, gasoline, residual fuel oil. For peat amount of distribution losses is also quite significant but this amount is not taken into account in RA reporting.

CSB reports the amount of fuel that was used in interproduct transfer but this amount is not reported in RA tables therefore the consumption of fuel in RA tables is reported although the fuel was not consumed in Latvia, for example, for other kerosene in 2004-2008.

The changes larger than 5% between fuel consumption in RA and Sectorial Approach (SA) are explained below for each fuel type.

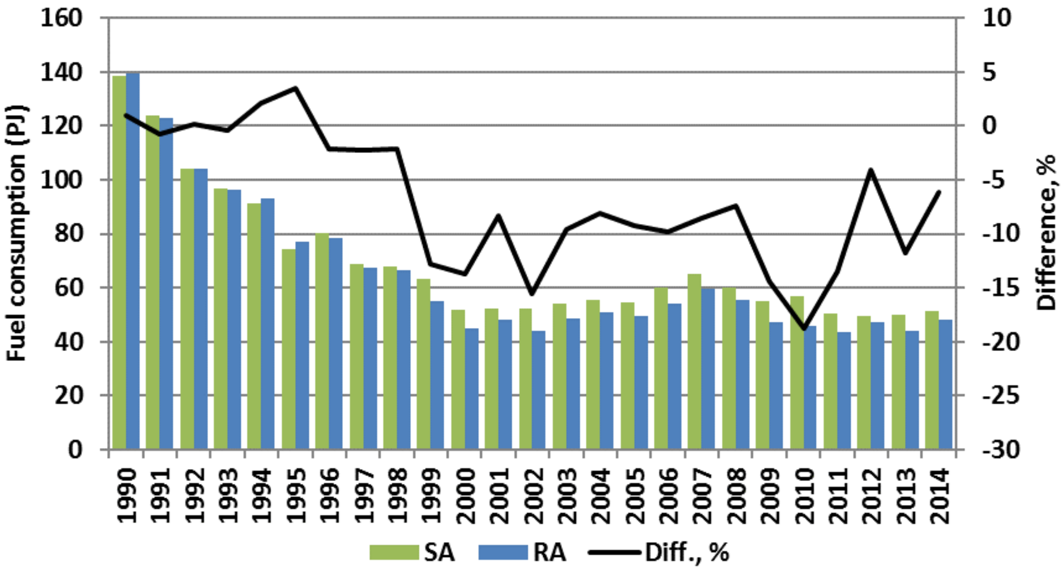


**Figure 3.5 Difference in fuel consumption of Liquid fuels between Reference and Sectoral Approach**

The difference between fuels varies from -2% to 4% until 1998, and with up to -18.77% difference in 2010 (Figure 3.5). The differences after 1998 can be generally explained with statistical differences in diesel oil energy balance which are not taken into account when calculating RA, and also with interproduct transfers of RFO, shale oil, jet fuel and kerosene. In 1999, there are also large statistical differences in gasoline consumption (-6.38 PJ).

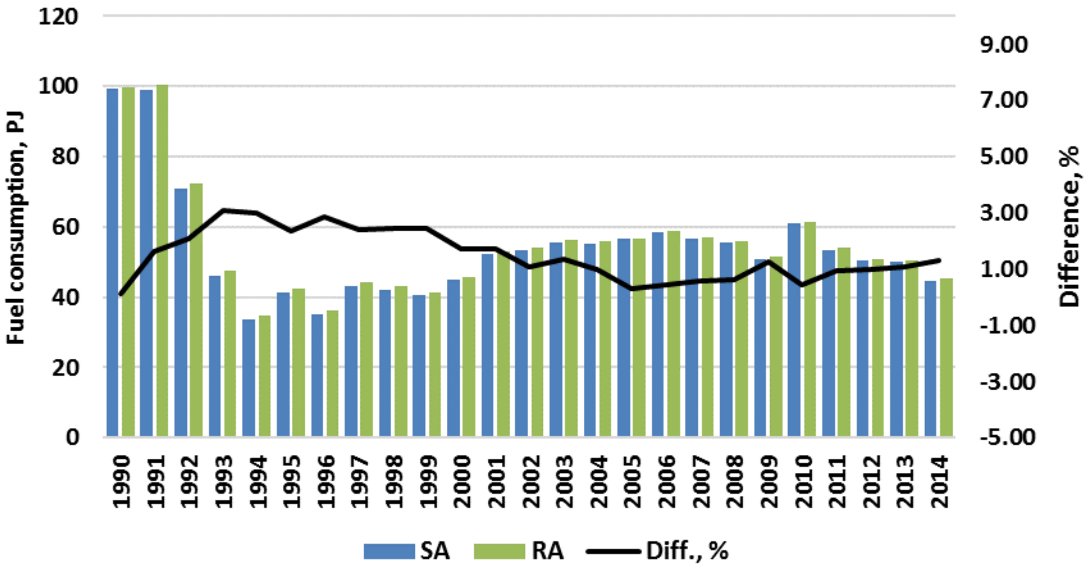


**Figure 3.6 Difference in fuel consumption of Gaseous fuels between Reference and Sectoral Approach**

The differences in natural gas consumption between both approaches are mainly due to distribution losses that occur every year (Figure 3.6).

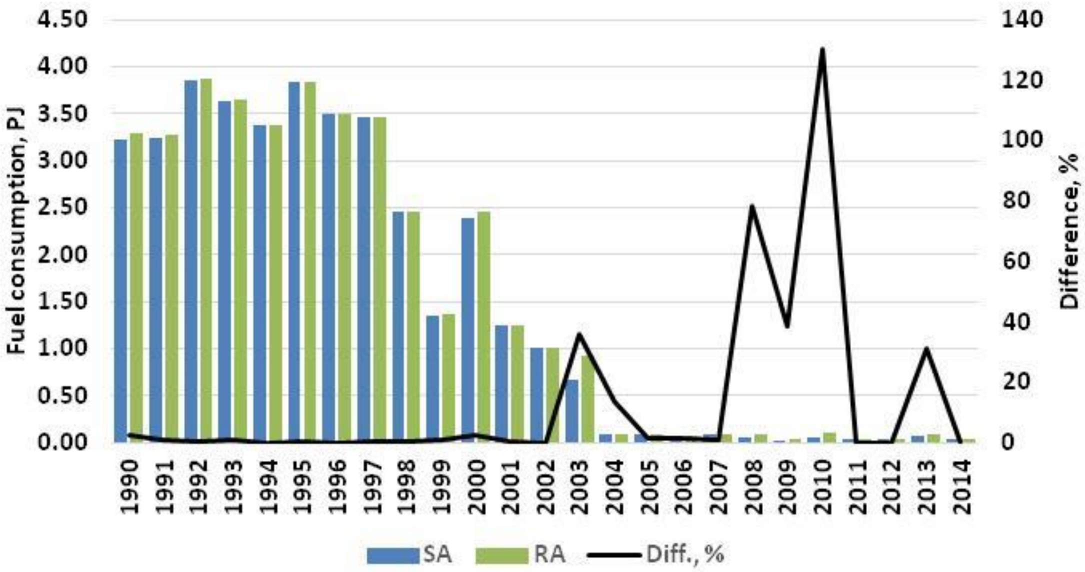


**Figure 3.7 Difference in fuel consumption of Peat (including Peat briquettes) between Reference and Sectoral Approach**

Among all fuel types, for peat and peat briquettes the differences are the most remarkable (Figure 3.7). It is because in the recent years there are significant losses of peat reported by CSB, for example, in 2003, there are 241 TJ reported by CSB as peat losses, and it can be clearly seen in difference of RA and SA - while the total consumption according to RA is 914 TJ, within SA only 673 TJ are reported. The same applies to years 2008-2011 and 2013, where losses of peat are around 10-60 TJ.

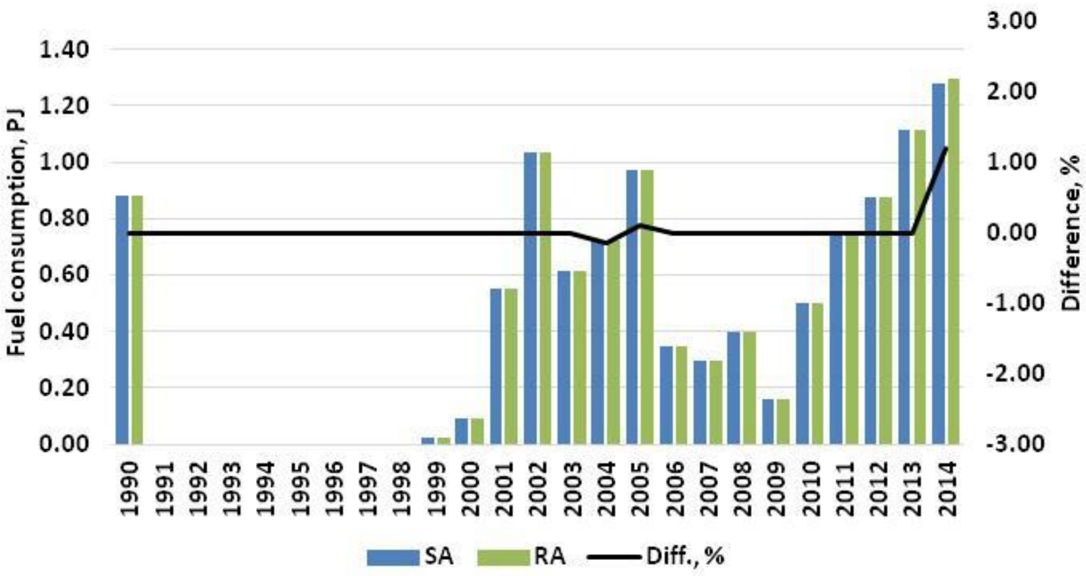


**Figure 3.8 Difference in consumption of Other fuels between Reference and Sectoral Approach**

The differences for Other fuels are not larger than ±5% (Figure 3.8), therefore not analysed.

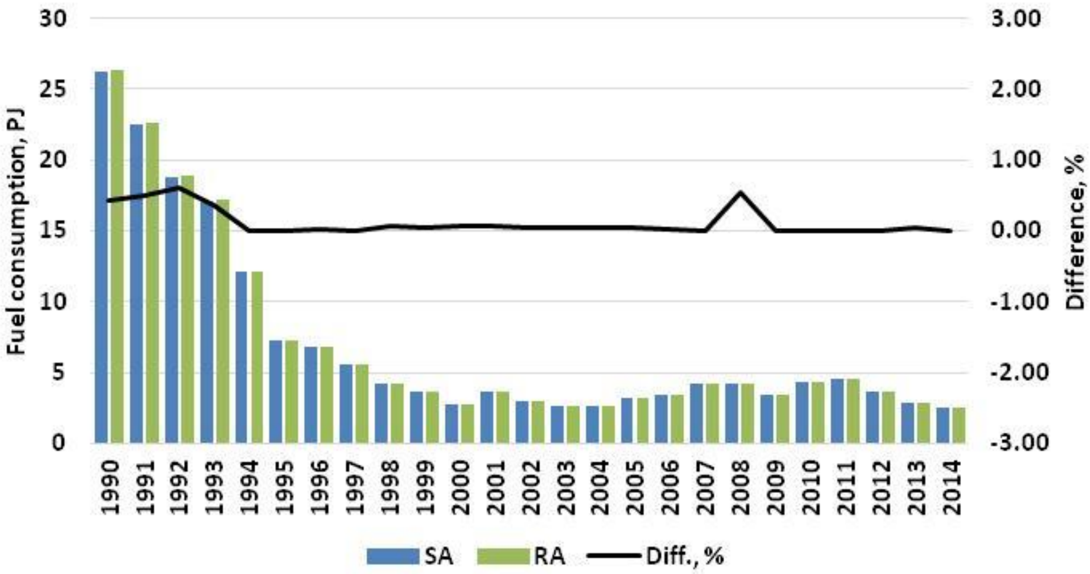


**Figure 3.9 Difference in consumption of Solid fuels between Reference and Sectoral Approach**

The differences for solid fuels are not larger than ±5% (Figure 3.9), therefore not analysed.

#### 3.2.1.2 Explanation of the fluctuations

Fluctuations of emissions estimated with SA and RA are more or less equal. All fuels had decreased in 1990-1995 due to continued changes of national economy structure, inflation and collapse of national industry. Still in 1995-1996 the government adopted strict rules to cut back the inflation and downward of industry so the fuel consumption since 1995-1996 also was restructured. Since 1996 the natural gas consumption is increasing but other fuel consumption are increasing only after 2000 due to development of national economy that was prepared for joining European Union. In the recent years there can be seen the influence of global economic crisis in 2007-2009 and a recovery after that in 2010-2014 with a decreasing trend of emissions.

### 3.2.1.3 Methodological issues

2006 IPCC Guidelines Reference approach for the $CO_2$ emission estimations and comparison of $CO_2$ emissions were used. CRF Reporter software was used to report emission data. Annual import, export, production, international bunkers and stock changes data divided by fuel types are put in the RA tables of CRF Reporter as well as carbon emission factor (EF) and coefficient of fraction of carbon oxidized.

Generally emissions are calculated by multiplying fuel consumption with country specific, plant specific or IPCC default carbon EF taking into account fraction of carbon oxidized.

Carbon emission factors were estimated by taking into account net calorific values and the molecular weight ratio of the carbon and $CO_2$. Net calorific values (NCV) of the fuels are taken from Energy Balance prepared by CSB. The fuel consumers reported the NCV of the used fuels to CSB according to national legislation that obliges the enterprises that do any fuel use activities report it to CSB. The consumption of fuels is taken from CSB on-line database due to more precise data as in Annual Questionnaires, therefore, in order to improve transparency of the reporting, it was decided to use data from Energy Balance instead of Annual Questionnaires.

For peat, gasoline, diesel oil, RFO, shale oil, jet fuel, kerosene, wood, used oils and natural gas carbon emission factor is assumed as country specific. For several fuels NCV changes once in whole time series in 2003-2004 or 2002-2003 but for natural gas and municipal waste NCV and also carbon emission factor changes for every year in whole time series. NCV and carbon emission factor ($C_{EF}$) of other liquid fuels changes in every year in time series are explained with the fluctuation of other oil fuel structure (biogasoline, biodiesel, other liquid biofuels – bioethanol). Municipal waste structure also influenced carbon emission factor change in 2008-2013.

**Table 3.9 Carbon emission factors (t/TJ)**

| | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Peat** | 28.925 | 28.925 | 28.925 | 28.925 | 28.925 | 28.925 | 28.925 | 28.925 | 28.925 | 28.925 | 28.925 | 28.925 | 28.925 |
| **Gasoline** | 18.893 | 18.893 | 18.893 | 18.906 | 18.906 | 18.906 | 18.906 | 18.906 | 18.906 | 18.906 | 18.906 | 18.906 | 18.906 |
| **Diesel oil** | 20.400 | 20.400 | 20.400 | 20.400 | 20.400 | 20.400 | 20.400 | 20.400 | 20.400 | 20.400 | 20.400 | 20.400 | 20.400 |
| **RFO** | 21.113 | 21.113 | 21.113 | 21.113 | 21.113 | 21.113 | 21.113 | 21.113 | 21.113 | 21.113 | 21.113 | 21.113 | 21.113 |
| **Shale oil** | 21.047 | 21.047 | 21.047 | 21.047 | 21.047 | 21.047 | 21.047 | 21.047 | 21.047 | 21.047 | 21.047 | 21.047 | NO |
| **LPG** | 17.126 | 17.126 | 17.126 | 17.126 | 17.126 | 17.126 | 17.126 | 17.126 | 17.126 | 17.126 | 17.126 | 17.126 | 17.126 |
| **Jet fuel** | 19.718 | 19.718 | 19.718 | 19.713 | 19.713 | 19.713 | 19.713 | 19.713 | 19.713 | 19.713 | 19.713 | 19.713 | 19.713 |
| **Kerosene** | 19.715 | 19.715 | 19.715 | 19.715 | 19.715 | 19.715 | 19.715 | 19.715 | 19.715 | 19.715 | 19.715 | 19.715 | 19.715 |
| **Wood** | 30.015 | 30.015 | 30.015 | 30.015 | 30.015 | 30.015 | 30.015 | 30.015 | 30.015 | 30.015 | 30.015 | 30.015 | 30.015 |
| **Used oils** | 20.012 | 20.012 | 20.012 | 28.659 | 28.659 | 28.659 | 28.659 | 28.659 | 28.659 | 28.659 | 28.659 | 28.659 | 28.659 |
| **Natural gas** | 15.043 | 15.174 | 15.193 | 15.160 | 15.169 | 15.169 | 15.160 | 15.173 | 15.151 | 15.148 | 15.120 | 14.874 | 14.883 |
| **Landfill gas, sludge gas, other biogas** | NO | 13.953 | 13.953 | 13.953 | 13.953 | 13.953 | 13.953 | 13.953 | 13.953 | 13.953 | 13.953 | 13.953 | 13.953 |

| | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Industrial waste** | NO | NO | 16.515 | 15.536 | 15.536 | 15.536 | 16.624 | 16.624 | 13.647 | 15.565 | 14.994 | 15.743 | 16.532 |
| **Municipal waste (non-biomass)** | NO | NO | NO | NO | NO | NO | 12.052 | 11.961 | 9.581 | 7.640 | 8.849 | 13.767 | 10.552 |
| **Petroleum coke** | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | NO |
| **Anthracite** | NO | NO | NO | NO | NO | NO | NO | NO | NO | 26.800 | 26.800 | 26.800 | NO |
| **Peat briquettes** | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 | 26.600 |
| **Waste oils** | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 |
| **Straws** | 27.300 | 27.300 | 27.300 | 27.300 | 27.300 | 27.300 | 27.300 | 27.300 | 27.300 | 27.300 | 27.300 | 27.300 | 27.300 |
| **Charcoal** | 30.500 | 30.500 | 30.500 | 30.500 | 30.500 | 30.500 | 30.500 | 30.500 | 30.500 | 30.500 | 30.500 | 30.500 | 30.500 |
| **Oil shale** | 29.100 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | 25.800 | 25.800 | 25.800 | 25.800 | 25.800 | 25.800 | 25.800 | 25.800 | 25.800 | 25.800 | 25.800 | 25.800 | 25.800 |
| **Coke** | 29.200 | 29.200 | 29.200 | 29.200 | 29.200 | 29.200 | 29.200 | 29.200 | 29.200 | 29.200 | 29.200 | 29.200 | NO |
| **Other oil** | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 | 20.000 |
| **Biogasoline, biodiesels** | NO | NO | NO | 19.300 | 19.300 | 19.300 | 19.300 | 19.300 | 19.300 | 19.300 | 19.300 | 19.300 | 19.300 |

Carbon emission factors for petroleum coke, anthracite, peat briquettes, waste oils, straws, charcoal, oil shale, coal, coke, other oil, biogasoline, biodiesels and other liquid biofuels taken from 2006 IPCC Guidelines were used (Table 3.9). Carbon emission factor for industrial and municipal waste was estimated based on $CO_2$ emission factor reported by cement production plant within ETS.

### 3.2.1.4 Time-series consistency

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. Emissions from all sectors are estimated or reported as not occurring / not applicable therefore there are no "not estimated" sectors.

### 3.2.1.5 Category-specific QA/QC and verification

The best way to check RA data is to compare them with SA data that is done already in CRF Reporter. The difference between these two emission estimation and reporting methodologies has to be double-checked and explained.

There are several ways to do the checks of the activity data:

- Energy sector data is taken from the Energy Balance that CSB prepares annually, and it has the internal QA/QC procedures based on mathematical model and analysis to avoid logic mistakes.
- Data of RA are verified by CSB within National Inventory System Quality assurance process and in case of inconsistency of data reported in NIR and in CRF with the data in Energy balance of CSB and data reported to EUROSTAT by CSB all the information of data mismatch is reported to LEGMC. After that Energy sector's sectoral expert check all again the reported data and incorporate necessary changes in CRF and in

NIR. If the sectoral expert doesn't agree with reported data mismatch and considers that no changes are necessary the information of this is again sent to CSB with detailed explanation.

Estimated $CO_2$ emissions are checked:

- By comparing the emissions estimated with Reference Approach and Sectoral approach. All significant differences (more than 5%) are double-checked. Difference has to be explained and agreed with CSB. This verification step is done for total fuel combustion sector.
- By comparing used carbon emission factor with $CO_2$ emission factors used in Sectoral Approach.

### 3.2.2 International bunker fuels

International bunkers cover international aviation and navigation according to the 2006 IPCC Guidelines. Emissions from international aviation and navigation are not included into national total emissions. Taking into consideration the fact that ports in Latvia are focused on transit cargo transport, navigation activities have big fluctuations and depend on neighbouring countries' economical and international trading activities and competitiveness of Latvian ports' with other neighbouring ports in Baltic Sea. At the same time emissions from aviation are more stable, and recent trend depicts a persistent increase. In 2014, total GHG emissions of International Bunkering (see Figure 3.10), compared to 2013 level has decreased by 4.3%. In different subsectors various changes have taken place in 2014. In international aviation the GHG emissions has decreased by 10.9%, whereas in the international navigation it has decreased by 1.1 %. In different subsectors various changes have taken place in 2014. In international aviation GHG emissions have decreased by 10.9%, whereas in the international navigation it has decreased by 1.1 %.

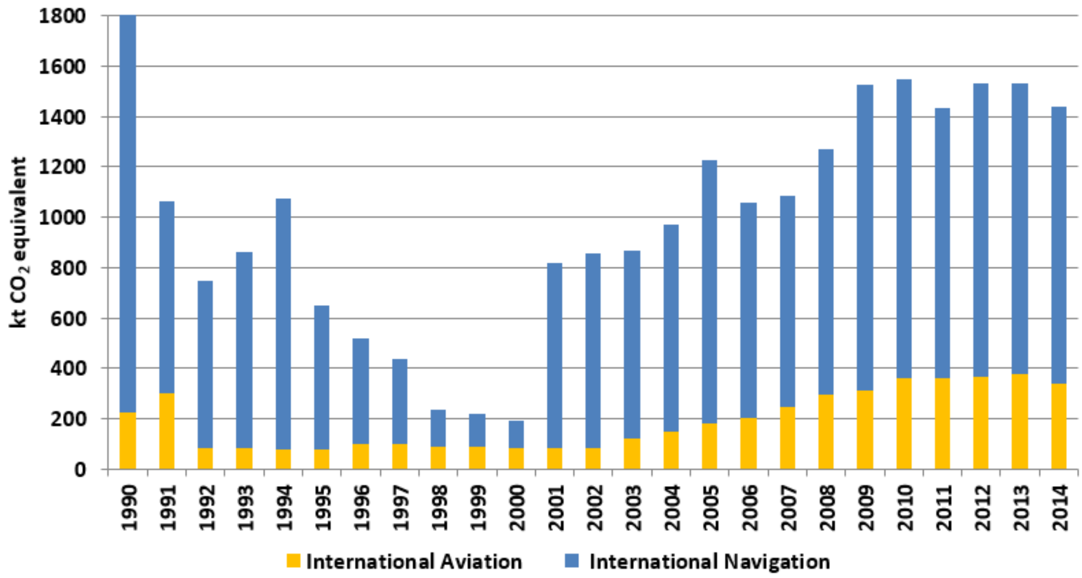


**Figure 3.10 Emissions from International Bunkers (kt $CO_2$ eq.)**

Data about international bunker fuel consumption is provided by CSB (Table 3.10). CSB split of fuel for national and international navigation/aviation is based on EUROSTAT and IEA guidelines on data collection. Defined approach about energy consumption allocation for international and national navigation/aviation fully is in line with the defined criteria in IPCC GPG 2000 (for more details see "Energy Statistics Manual", IEA, EUROSTAT (2005)). In Latvia's case there are no situations when international marine/aviation transport departs from port in Latvia and arrives in port in Latvia to drop-off and picks up passengers or freight and then departs for a final destination in other country. Therefore, implemented data collections of fuel consumption in international and national navigation/aviation fully ensure a correct allocation between national and international mode.

To provide consistent allocation of fuel consumption between domestic and international mode in the navigation and aviation, CSB each month collects and summarizes the information which is submitted by every enterprise which performs fuel bunkering; For this purpose, the particular statistical report format is elaborated in which the enterprises have to fill in the data regarding amount of fuel sold respectively in domestic and international navigation and aviation.

**Table 3.10 Energy consumption in international transport[16] (TJ)**

| | Aviation | Navigation | |
|---|---|---|---|
| | Jet Kerosene | Diesel Oil | Residual Fuel Oil (RFO) |
| **1990** | 3067 | 5014 | 14738 |
| **1995** | 1080 | 1105 | 5156 |
| **2000** | 1123 | 340 | - |
| **2001** | 1123 | 4249 | 3938 |
| **2002** | 1166 | 3612 | 4994 |
| **2003** | 1685 | 3102 | 4750 |
| **2004** | 2031 | 3187 | 5278 |
| **2005** | 2463 | 3824 | 7064 |
| **2006** | 2765 | 2762 | 5481 |
| **2007** | 3371 | 2507 | 4953 |
| **2008** | 4051 | 1912 | 6699 |
| **2009** | 4278 | 2592 | 8851 |
| **2010** | 4907 | 2932 | 7592 |
| **2011** | 4921 | 3187 | 5800 |
| **2012** | 4984 | 3697 | 6374 |
| **2013** | 5142 | 3148 | 6658 |
| **2014** | 4580 | 2932 | 6780 |

In 2014, $CO_2$ emissions from international aviation, compared to 2013 level, have decreased by 10.9% (Figure 3.10) due to decreasing fuel consumption. These changes in fuel consumption directly related to decreasing flights in Riga airport (decreasing around 2.5%) and by using more efficient airliners.

$CO_2$ emissions from the international navigation are affected by fuel consumption, which depends on several factors:

[16] *CSB. Annual Eurostat Energy Questionnaire, 2014*

- On the one hand it is affected by the port activity indicators (loaded, unloaded cargo). As shown in Figure 3.11, the total loaded and unloaded cargo volume in 2014 has increased by nearly 30% compared to 2001. At the same time the structure of the cargo handled has changed (see Figure 3.12). The main changes have affected the oil transshipment, whose share in handeled cargo volume has decreased from 18.7% to 0.2%. At the same time, the coal share in the total handled cargo volume has increased from 9.7% to 37.3 %.
- On the other hand, fuel consumption is affected by the number of vessels serviced in ports. As shown in Figure 3.11, in spite of the rapid increase in the volume of cargo at the port of Riga, the number of serviced ships has remained almost unchanged or even has decreased. The main reason for this trend is the increase in the gross tonnage of vessels. The most significant increase was registered in the average tanker gross tonnage, but also in other cargo carrier groups (container, dry bulk carriers). All this confirms the fact that the cargo owners continue to optimize transport costs including fuel costs and try to use larger vessels where possible.

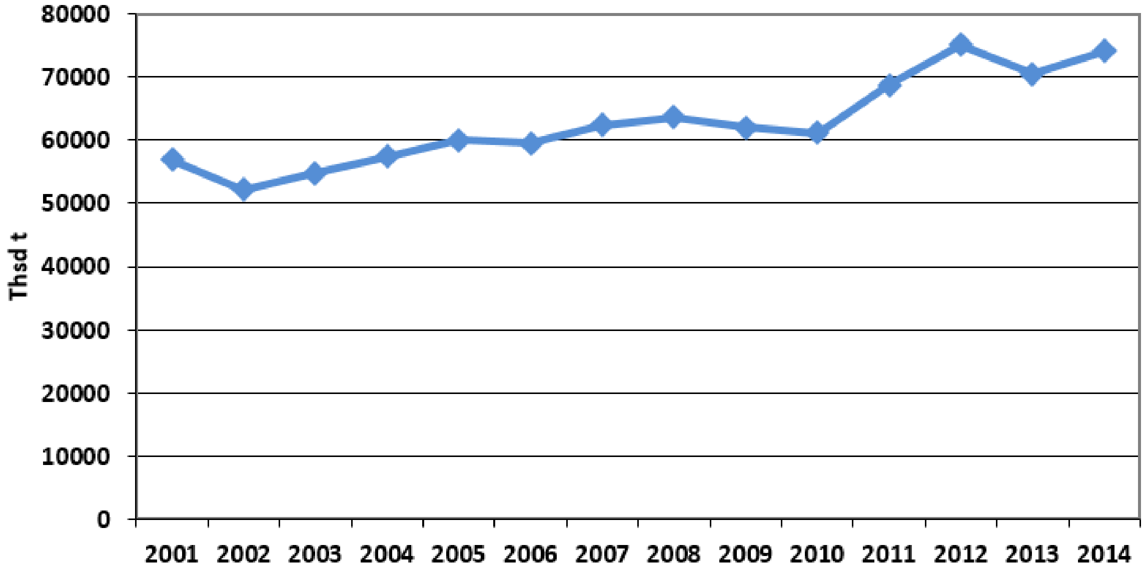


**Figure 3.11 Loaded, unloaded cargo at ports in Latvia (Thsd t)**

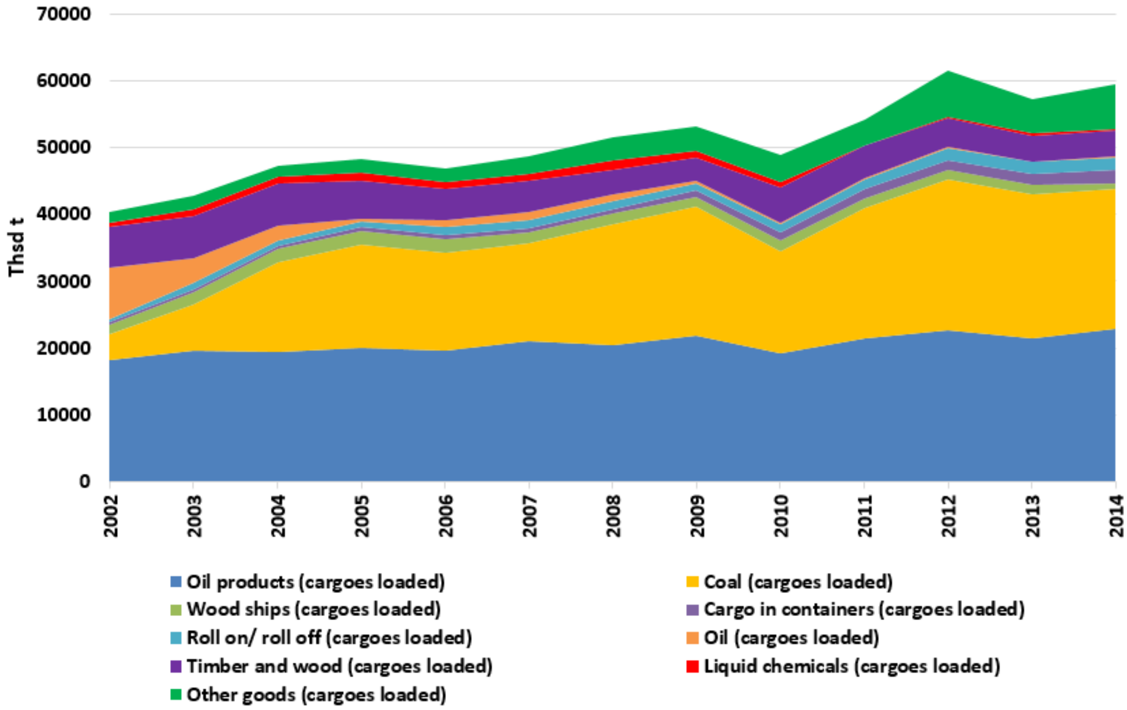


**Figure 3.12 Structure of loaded goods at ports in Latvia (Thsd t)**

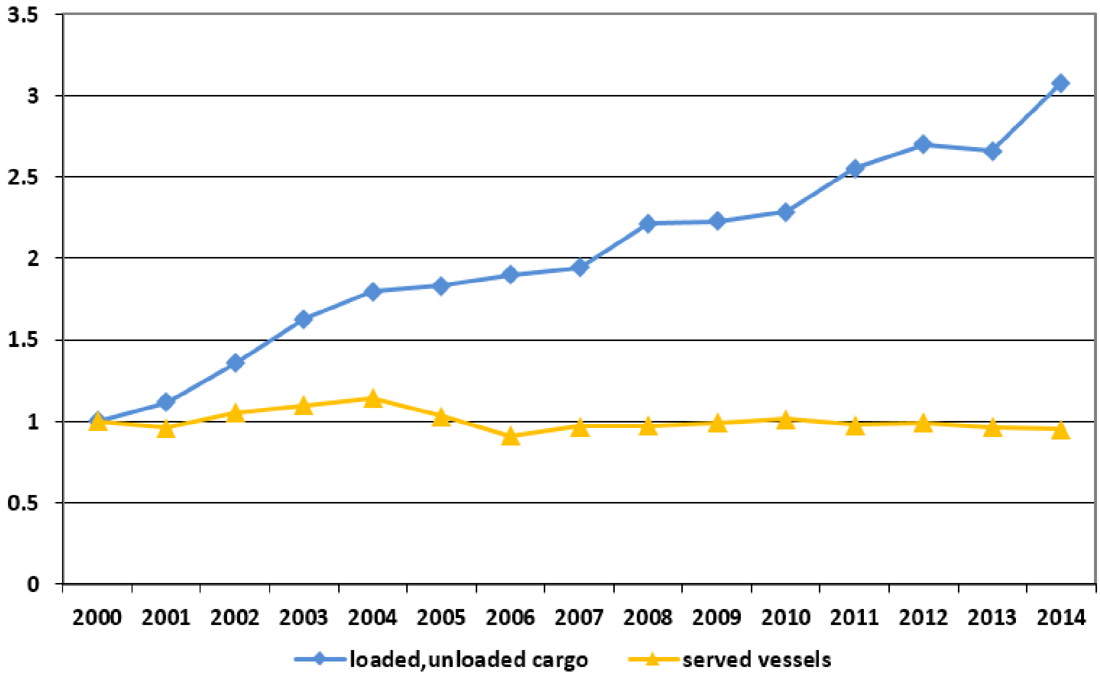


**Figure 3.13 Loaded, unloaded cargo and served vessels at Riga port (2000 = 1)**

The implemented emission factors for emission calculation from international navigation are shown in Table 3.13.

**Table 3.11 Emission factors used in the calculation of emissions from International Bunkering**

| | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC |
|---|---|---|---|---|---|---|
| | kt/PJ | kt/PJ | kt/PJ | kt/PJ | kt/PJ | kt/PJ |
| **Diesel oil** | 74.0 | 0.004 | 0.03 | 1.8475 | 0.1742 | 0.0659 |
| **RFO** | 76.6 | 0.005 | 0.002 | 1.9532 | 0.1822 | 0.0665 |

The methodology used for calculation of emissions from international aviation corresponds to the 2006 IPCC Guidelines Tier 2 where the amount of LTO (landing and take-off)/cruises is crucial. Emissions from international navigation are calculated in pursuance with 2006 IPCC Guidelines Tier 1.

The relevant emission factors are taken from different sources. All of the international aviation and navigation emission factors ($CO_2$, $CH_4$ and $N_2O$) are derived from the 2006 IPCC Guidelines, while the remaining factors – from EMEP/EEA 2013 for determination of $SO_2$ EF country-specific sulphur content is applicable (see Table 3.12 and Table 3.13).

**Table 3.12 $SO_2$ Emission factors used for diesel oil in the $SO_2$ calculation of emissions International Bunkering**

| Diesel oil | Fuel content | NCV | EF (kt/PJ) |
|---|---|---|---|
| **1990-2002** | 0.2 | 42.49 | 0.094 |
| **2003-2004** | 0.05 | 42.49 | 0.024 |
| **2004-2007** | 0.2 | 42.49 | 0.094 |
| **2008-2014** | 0.1 | 42.49 | 0.047 |

**Table 3.13 $SO_2$ Emission factors used for RFO in the $SO_2$ calculation of emissions International Bunkering**

| RFO | Fuel content | NCV | EF (kt/PJ) |
|---|---|---|---|
| **1990-2007** | 2.8 | 40.6 | 1.352 |
| **2007-2014** | 1.5 | 40.6 | 0.74 |

## 3.2.3 Feedstocks and non-energy use of fuels (CRF 1.AD)

### 3.2.3.1 Category description

Under this category consumption of different types of fuels used as feedstock is reported. Emissions from these fuels are reported as "$CO_2$ not emitted" because it is assumed that in $CO_2$ emissions is captured and not emitted to the air.

Consumption of Bitumen, Lubricants, Coke, White spirits and Paraffin wax is reported in 1.D tables for all years in time series 1990–2014.

### 3.2.3.2 Methodological issues

Carbon emission factors used in 2006 IPCC Guidelines were taken for all fuel types – Bitumen (22 t/TJ), Lubricants (20 t/TJ), Coke (29.2 t/TJ), White spirits (20 t/TJ) and Paraffin waxes (20 t/TJ).

Activity data prepared by CSB and available on CSB on-line database were used (Table 3.14).

**Table 3.14 Activity data for Feedstocks and Non-energy use of fuels in 1990–2014 (TJ)**

| | Bitumen | Lubricants | Coke | White spirits | Paraffin waxes |
|---|---|---|---|---|---|
| **1990** | 1633 | 1633 | 53 | 84 | NO |
| **1991** | 544 | 1047 | 105 | 84 | NO |
| **1992** | 84 | 921 | 132 | 84 | NO |
| **1993** | 167 | 1088 | 105 | 84 | NO |
| **1994** | 544 | 1005 | 185 | 84 | NO |
| **1995** | 712 | 963 | 158 | 84 | NO |
| **1996** | 879 | 963 | 158 | 84 | NO |
| **1997** | 1633 | 879 | 264 | 84 | NO |
| **1998** | 2051 | 1005 | 264 | 126 | NO |
| **1999** | 2344 | 879 | 264 | 84 | 126 |
| **2000** | 2009 | 879 | 264 | 126 | 126 |
| **2001** | 1507 | 837 | 264 | 126 | 167 |
| **2002** | 2093 | 837 | 241 | 84 | 167 |
| **2003** | 2177 | 921 | 134 | 84 | 167 |
| **2004** | 2009 | 1005 | 161 | 126 | 251 |
| **2005** | 2512 | 1088 | 134 | 126 | 335 |
| **2006** | 3098 | 1088 | 129 | 126 | 251 |
| **2007** | 3349 | 1088 | 107 | 84 | 251 |
| **2008** | 3600 | 1047 | 134 | 84 | 209 |
| **2009** | 2218 | 628 | 134 | 42 | 293 |
| **2010** | 1967 | 586 | 80 | 40 | 461 |
| **2011** | 2930 | 795 | 80 | 42 | 293 |
| **2012** | 2888 | 922 | 161 | 42 | 251 |
| **2013** | 3181 | 880 | 52 | 42 | 377 |
| **2014** | 2930 | 632 | 0.17 | 42 | 335 |

Constant increase of bitumen use since 2004 until 2008 is explained with development of construction sector and availability of financial resources from European Union (Latvia is a member of European Union since 2004) for building and improvement of transportation infrastructure. However, during the economic crisis the funding reduced and the amounts of bitumen used decreased in 2008-2010. After the financial crisis increase in bitumen use can be observed. Lubricants are mainly used in transport sector.

Coke is used as ingredient in metallurgy to produce higher quality steel. Evident decrease in coke use can be explained with changes in metallurgy. Financial crisis in 2010 and bankruptcy of "Liepājas metalurgs" is the reason of reduced metal production and use of coke.

Paraffin waxes and white spirits mainly are used as feedstocks in chemical industry and wood processing.

## 3.2.4 Energy Industries (CRF 1.A.1)

### 3.2.4.1 Category description

CRF 1.A.1 Energy Industries sector includes emissions from fuel combustion in point sources in energy and heat production. According to 2006 IPCC Guidelines, emissions from autoproducers (undertakings which generate electricity/heat wholly or partly for their own use, as an activity that supports their primary activity) are assigned to the sector where they were generated and not under CRF 1.A.1.

Emissions from combustion installations with NACE 2 codes 35.11 and 35.30 are reported in CRF 1.A.1.a sector. There are no petroleum refineries in Latvia therefore in CRF 1.A.1.b notation key „NO" is used. CRF 1.A.1 sector also includes the emissions from on-site use of fuel in the energy production facilities and emissions from manufacturing of solid fuels (peat briquettes and charcoal production plants) – these emissions are reported under 1.A.1.c Manufacture of solid fuels and other energy industries sector.

In Submission 2016, the CRF subsector 1.A.1. was split into subsectors which are in line with 2006 IPCC Guidelines/CRF Reporter structure. The GHG emissions were reported under following ones:

- 1. A.1. Energy industries:
- 1.A.1.a. Public electricity and heat production:
    - 1.A.1.a.i Electricity generation;
    - 1.A.1.a.ii Combined heat and power generation;
    - 1.A.1.a.iii Heat plants;
- 1.A.1.c. Manufacture of solid fuels and other energy industries:
    - 1.A.1.c.i Manufacture of solid fuels.

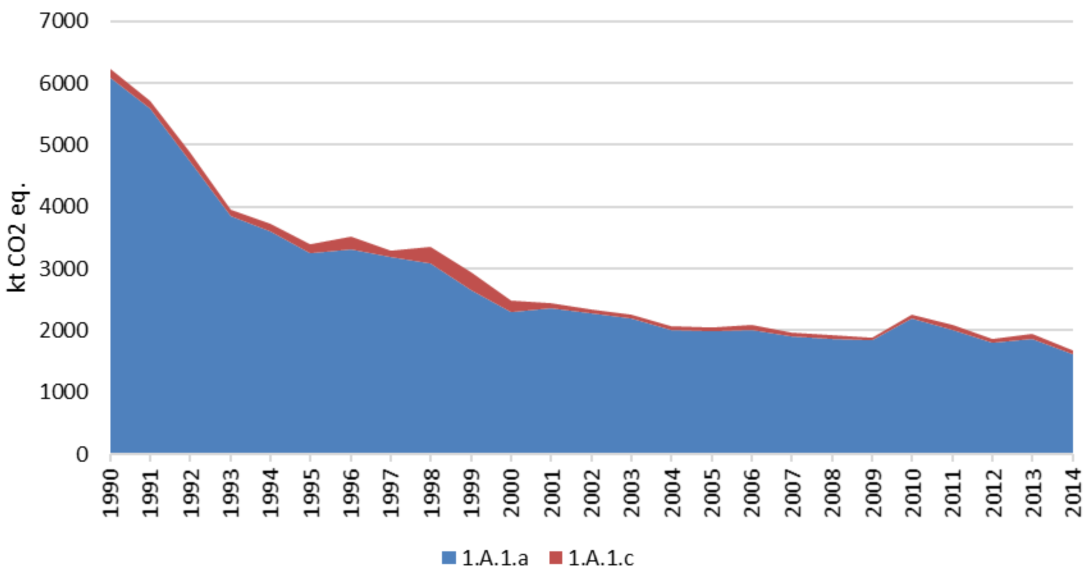


**Figure 3.14 GHG emissions in CRF 1.A.1. Energy industries by subsectors (kt $CO_2$ eq.)**

In Figure 3.14, there can be seen the distribution of GHG emissions in CRF 1.A.1. sector. The largest part of emissions consists of CRF 1.A.1.a Public electricity and heat production (96.0% in 2014), while CRF 1.A.1.c Manufacture of solid fuels and Other energy industries contribute to 4.0% of Energy industry emissions. As mentioned above, there are no emissions in CRF 1.A.1.b Petroleum refining.

**Table 3.15 Emissions from Energy industries (CRF 1.A.1) in 1990–2014 (kt)**

| | $CO_2$ | $CH_4$ | $N_2O$ | Aggregate GHGs | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|---|
| | kt | | | kt $CO_2$ eq. | kt | | | |
| **1990** | 6201.22 | 0.19 | 0.038 | 6217.15 | 10.54 | 2.61 | 0.22 | 36.39 |
| **1991** | 5692.55 | 0.17 | 0.033 | 5706.81 | 9.65 | 2.56 | 0.21 | 29.52 |
| **1992** | 4861.46 | 0.15 | 0.031 | 4874.39 | 8.34 | 2.09 | 0.17 | 26.86 |
| **1993** | 3939.64 | 0.14 | 0.030 | 3951.90 | 7.07 | 1.48 | 0.13 | 28.30 |
| **1994** | 3712.96 | 0.15 | 0.032 | 3726.19 | 6.92 | 1.28 | 0.13 | 32.20 |
| **1995** | 3391.71 | 0.12 | 0.026 | 3402.54 | 6.25 | 1.39 | 0.12 | 22.83 |
| **1996** | 3511.75 | 0.15 | 0.030 | 3524.56 | 6.54 | 1.32 | 0.13 | 28.61 |
| **1997** | 3275.72 | 0.19 | 0.032 | 3289.98 | 6.10 | 1.70 | 0.14 | 19.66 |
| **1998** | 3338.13 | 0.21 | 0.035 | 3354.03 | 6.11 | 1.75 | 0.15 | 20.84 |
| **1999** | 2919.47 | 0.19 | 0.030 | 2933.20 | 5.24 | 1.61 | 0.13 | 16.02 |
| **2000** | 2474.11 | 0.15 | 0.024 | 2485.18 | 4.40 | 1.56 | 0.12 | 7.64 |
| **2001** | 2421.19 | 0.17 | 0.025 | 2432.76 | 4.37 | 1.75 | 0.13 | 5.51 |
| **2002** | 2317.01 | 0.18 | 0.026 | 2329.19 | 4.23 | 1.75 | 0.13 | 5.22 |
| **2003** | 2246.23 | 0.20 | 0.028 | 2259.58 | 4.15 | 1.86 | 0.14 | 4.50 |
| **2004** | 2056.91 | 0.20 | 0.026 | 2069.73 | 3.78 | 1.78 | 0.13 | 3.12 |
| **2005** | 2047.02 | 0.17 | 0.023 | 2058.12 | 3.70 | 1.73 | 0.12 | 2.01 |
| **2006** | 2073.74 | 0.19 | 0.025 | 2085.85 | 3.77 | 1.85 | 0.13 | 1.37 |
| **2007** | 1944.72 | 0.19 | 0.024 | 1956.65 | 3.57 | 1.74 | 0.12 | 1.35 |
| **2008** | 1917.50 | 0.18 | 0.024 | 1929.12 | 3.51 | 1.73 | 0.12 | 0.78 |
| **2009** | 1866.76 | 0.18 | 0.024 | 1878.48 | 3.44 | 1.68 | 0.12 | 0.82 |
| **2010** | 2249.66 | 0.20 | 0.027 | 2262.68 | 4.10 | 2.02 | 0.14 | 0.89 |
| **2011** | 2071.47 | 0.19 | 0.025 | 2083.53 | 3.81 | 1.87 | 0.13 | 0.65 |
| **2012** | 1855.35 | 0.22 | 0.029 | 1869.28 | 3.62 | 1.85 | 0.13 | 0.60 |
| **2013** | 1918.68 | 0.32 | 0.043 | 1939.40 | 4.07 | 2.25 | 0.16 | 0.63 |
| **2014** | 1660.91 | 0.38 | 0.050 | 1685.30 | 3.82 | 2.29 | 0.17 | 0.60 |
| **Share of Energy total, 2014** | 25.4% | 3.1% | 13.5% | 24.2% | 12.8% | 1.8% | 0.8% | 15.0% |
| **2014 vs 2013** | -13.4% | 18.0% | 17.5% | -13.1% | -6.3% | 1.4% | 2.8% | -4.4% |
| **2014 vs 1990** | -73.2% | 101.3% | 32.7% | -72.9% | -63.8% | -12.5% | -22.9% | -98.4% |

$CO_2$ emissions from CRF 1.A.1 sector have a decreasing trend with a few fluctuations from which the most recent were in 2010 (Table 3.15). Since 1990, $CO_2$ emissions have decreased by 73.2% (biomass emissions excluded). In the beginning of the 90's the decrease of $CO_2$ emissions is explained with economic crisis caused by changes of political and social situation in the country when national economy was completely reorganized. Decrease in the end of 90's is explained with economic crisis in Russian Federation with which Latvia has close economic cooperation. Although heat and electricity production for public use was influenced by 2008-2009 economic crisis, although in smaller level than heat and electricity production for industrial sector, the emissions were decreasing as population was using less electricity and residential sector switched from central district heating to individual heating. Also, the following decrease of emissions can be explained with higher standards of physical specification of fuels and fuel switching to fuels with lower costs and emissions – natural gas and biomass. In recent years, an increase of $CO_2$ emissions in 2010 can be explained with extremely cold winter, and the decrease in 2011 – with much warmer one, which influenced the amounts of fuel used for heating. Since 2010 up to year 2014, the emissions of $CO_2$ have decreased by 26.2%.

Nevertheless, in $CH_4$ and $N_2O$ emissions there can be seen an increase in recent years, starting from 2011, due to increased use of liquid solid and biomass fuel consumption. Since 2011 up to year 2014 the increase in $CH_4$ and $N_2O$ emissions was 102.0% and 102.5%, respectively. If compared with decreasing $CO_2$ emissions, the increase in $CH_4$ and $N_2O$ emissions is because of biomass use – as it is considered as $CO_2$ neutral, it does not take place in $CO_2$ balance, however, biomass combustion is accounted for $CH_4$ and $N_2O$ emissions.

Indirect GHG emissions from CRF 1.A.1 Energy Industries were estimated as well. $SO_2$ had the biggest decrease by 98.4% in 1990–2014. It can be explained with fuel switching from coal, peat and heavy fuel oils to natural gas and biomass from what sulphur dioxide emissions are emitted in considerably smaller amounts. Also a strict national legislation was approved to improve the quality of used liquid fuels in country. NOx emissions have also decreased by 63.8% in 1990-2014, NMVOC emissions – by 22.9%, and CO emissions – by 12.5%. The decrease can also be explained with fuel switch from solid to natural gas and biomass, which have lower emission factors.

#### 3.2.4.2 Methodological issues

2006 IPCC Guidelines' Tier 2 method was used to estimate $CO_2$ emissions from fuel combustion as country specific parameters were used to estimate $CO_2$ emission factor. However, for some fuels there are no country-specific emission factors, therefore 2006 IPCC Tier 1 method using default emission factors was used. 2006 IPCC Guidelines' Tier 1 method was used to calculate $CH_4$ and $N_2O$ emissions from the CRF 1.A.1 sector.

As sludge gas consists approximately 35-44% of non-combustible components such as $CO_2$ sulphur and others and 56-65% of sludge gas is combustible, methane emissions from biogas were calculated only by taking into account the methane part of biogas. It means that under the biogas fuel the combustion of methane is reported. As methane is obtained from sludge it is considered as biomass combustion, hence $CO_2$ neutral. Therefore Tier 2 method from 2006 IPCC Guidelines was used to calculate $CO_2$ emissions from methane obtained from sludge gas as plant specific parameters were used to estimate $CO_2$ emissions from methane obtained from sludge gas.

Calculation of all emissions from fuel combustion is done with Excel databases developed by the experts from LEGMC. The general method for emission data preparation was used:

$$Em = EF \times B_q$$

*where:*
*Em – total emissions (kt)*
*EF – estimated or default emission factor (t/TJ)*
*$B_q$ – amount of fuel in thermal units (TJ)*

$NO_x$ and $SO_2$ emission data of 2005-2014 from combined heat and power plants as well as heat production only plants are taken from database "2-AIR" where enterprises that do any pollution activity and have A, B or C category pollution permits report their emission data, therefore these data are plant specific. Other indirect GHGs (CO, NMVOC) are calculated using Tier 1 method.

*Emission factors and other parameters*

The main sources for emission factors are:

- National studies for country specific parameters and emission factors;
- Data from only natural gas supplier company of natural gas physical characteristics;
- 2006 IPCC Guidelines;
- EMEP/EEA 2013.

Country specific emission factors were used to calculate carbon dioxide ($CO_2$) and sulphur dioxide ($SO_2$) emissions.

**$CO_2$ emission factors**

In 2004 a research by a local expert was made regarding $CO_2$ emission factors for Latvia in concern with IPCC 1996 and used fuel type of physical characteristics. National expert assessed indices that influences $CO_2$ emission factor and calculated $CO_2$ emission factor in the research "Methodological instructions for $CO_2$ emissions determination" (Annex A.3.2). This research was made considering United Nations framework convention of climate change recommendations of Intergovernmental Panel of Climate Change and physical characterizations of types of fuels used in Latvia.

Solid and liquid fuels and solid biomass

For calculating $CO_2$ emission factors for liquid and solid fuels following equation (Annex A.3.2) was used:

$$EF_{CO_2} = \frac{C^d \times M_{CO_2} \times 1000}{Q_d^z \times M_C \times 100}$$

*where:*
*$EF_{CO2}$ – emission factor for $CO_2$ (kg $CO_2$/MJ)*
*$Q_z^d$ – net calorific value of fuel (MJ/kg ($m^3$))*
*$C^d$ – carbon content in fuel (%)*
*$M_{CO2}$ – molecule weight for $CO_2$ – 44. 0098 (g/mcl)*
*$M_C$ – molecule weight for C – 12.011 (g/mcl)*

For Submission 2016 $CO_2$ emission factors for certain types of fuels were recalculated according to CSB reported information of NCV changes in time period. NCV value was obtained from fuel consumers that have to report the used amount data and other fuel information to CSB within annual reporting (Table 3.16).

**Table 3.16 Characteristics of liquid solid and solid biomass fuels and estimated $CO_2$ emission factors**

| Fuel type | Carbon content in working mass of fuel ($C^d$) % | NCV, GJ/t | Oxidation factor | Emission factor with oxidation factor (EF $CO_2$), t/TJ |
|---|---|---|---|---|
| **Peat $W_d$=40%** | 29.07 | 10.05 | 0.98 | 103.8664 |
| **Motor gasoline (for off-roads)** | 83.13 | 44 (1990-2002)<br>43.97 (2003-2014) | 0.99 | 68.5347<br>68.5815 |
| **Diesel oil** | 86.68 | 42.49 | 0.99 | 74.0010 |
| **RFO** | 85.72 | 40.6 | 0.99 | 76.5881 |
| **Shale oil** | 82.82 | 39.35 | 0.99 | 76.3477 |
| **LPG** | 77.99 | 45.54 | 0.995 | 62.4366 |

| Fuel type | Carbon content in working mass of fuel ($C^d$) % | NCV, GJ/t | Oxidation factor | Emission factor with oxidation factor (EF $CO_2$), t/TJ |
|---|---|---|---|---|
| **Jet fuel** | 85.18 | 43.2 (1990-2002)<br>43.21 (2003-2014) | 0.99 | 71.5252<br>71.5087 |
| **Other kerosene** | 85.17 | 43.2 (1990-2000)<br>43.21 (2004)<br>43.2 (2005-2014) | 0.99 | 71.5168 (NCV - 43.2)<br>71.5003 (NCV - 43.21) |
| **Used oils** | 83.77 | 41.86 | 0.99 | 72.5930 |
| **Wood**<br>**$W_d$ = 55%** | 20.11 | 6.7 | 0.98 | 107.7789 |

For some fuels default $CO_2$ emission factors from 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.2, were taken due to unavailability of country specific data:

- coal – 94.6ktg/PJ;
- coke – 107 kt/PJ;
- peat briquettes – 97.5 kt/PJ;
- biodiesel – 70.8 kt/PJ;
- straws – 100 kt/PJ;
- waste oils – 73.3 kt/PJ.

Natural gas

For calculating $CO_2$ emission factor for natural gas following equation (Annex A.3.2) was used:

$$EF_{CO_2} = \frac{C^d \times M_{CO_2}}{M_C \times 100} \times \rho$$

*where:*
*$EF_{CO2}$ – emission factor for $CO_2$ (kt/1000m$^3$)*
*$C^d$ – carbon content in fuel (%)*
*$M_{CO2}$ – molecule weight for $CO_2$ – 44.0098 (g/mcl)*
*Mc – molecule weight for C – 12.011 (g/mcl)*
*ρ – natural gas density – for transition from density to mass units (t/1000m$^3$)*

Data of carbon content and natural gas density for 1990-2014 were obtained from only natural gas supplier JSC "Latvijas Gāze" that collects/measures these data by themselves (Table 3.17). NCV values to calculate data further in energy units were taken from CSB.

**Table 3.17 Characteristics of natural gas and estimated $CO_2$ emission factors**

| | Carbon content in working mass of fuel ($C^d$) % | Oxidation factor (p) | Natural gas density (ρ) t/1000m$^3$ | Emission factor with oxidation factor (EF $CO_2$) kt/1000m$^3$ |
|---|---|---|---|---|
| **1990** | 74.33 | 0.995 | 0.6867 | 1.8703 |
| **1991** | 74.33 | 0.995 | 0.6867 | 1.8703 |
| **1992** | 74.36 | 0.995 | 0.6923 | 1.8863 |
| **1993** | 74.15 | 0.995 | 0.6965 | 1.8924 |
| **1994** | 74.04 | 0.995 | 0.6914 | 1.8757 |

| | Carbon content in working mass of fuel ($C^d$) % | Oxidation factor (p) | Natural gas density (ρ) t/1000m$^3$ | Emission factor with oxidation factor (EF $CO_2$) kt/1000m$^3$ |
|---|---|---|---|---|
| **1995** | 74.26 | 0.995 | 0.6889 | 1.8745 |
| **1996** | 74.3 | 0.995 | 0.6859 | 1.8673 |
| **1997** | 74.39 | 0.995 | 0.6845 | 1.8658 |
| **1998** | 74.35 | 0.995 | 0.6857 | 1.8680 |
| **1999** | 74.31 | 0.995 | 0.6841 | 1.8627 |
| **2000** | 74.32 | 0.995 | 0.6879 | 1.8733 |
| **2001** | 74.36 | 0.995 | 0.6876 | 1.8735 |
| **2002** | 74.36 | 0.995 | 0.6858 | 1.8686 |
| **2003** | 74.38 | 0.995 | 0.6851 | 1.8672 |
| **2004** | 74.39 | 0.995 | 0.6839 | 1.8641 |
| **2005** | 74.4 | 0.995 | 0.6835 | 1.8633 |
| **2006** | 74.39 | 0.995 | 0.6838 | 1.8639 |
| **2007** | 74.38 | 0.995 | 0.6828 | 1.8609 |
| **2008** | 74.38 | 0.995 | 0.6833 | 1.8622 |
| **2009** | 74.37 | 0.995 | 0.686 | 1.8694 |
| **2010** | 74.42 | 0.995 | 0.6855 | 1.8692 |
| **2011** | 74.43 | 0.995 | 0.6856 | 1.8698 |
| **2012** | 74.31 | 0.995 | 0.6855 | 1.8665 |
| **2013** | 74.34 | 0.995 | 0.6884 | 1.8751 |
| **2014** | 74.36 | 0.995 | 0.6919 | 1.8852 |

<u>Landfill gas</u>

There are five landfills in Latvia that collect biogas from landfills – one landfill is collecting and combusting biogas since 2002 second from 2003 third from 2004. Fourth landfill started to combust biogas with energy recovery only in 2008, but fifth – in 2013.

As landfills were not able to provide information of carbon content percentage in working mass of fuel constant methane value was used instead and was estimated basing on molar mass of components. Following equation (Annex A.3.2) was used to calculate this methane number:

$$C^d = \frac{M_C}{(M_C + M_H)} \times 100$$

*where:*
*$C^d$ – carbon content in fuel (%)*
*Mc – molecule weight for C – 12.011 (g/mcl)*
*$M_H$ – H molecule weight (1.008 g/mcl)*
*100 – estimation of percentage*

For calculation of $CO_2$ emission factor of methane obtained from landfill gas, an equation basically the same as for natural gas was used, although methane carbon content, density and NCV from scientific literature was used[17] (Table 3.18). The same assumption refers to other biogas.

[17] http://dolgikh.com/index/0-31

$$EF_{CO_2} = \frac{C^d \times M_{CO_2} \times 1000}{Q_d^z \times M_C \times 100} \times \rho$$

*where:*
*$EF_{CO2}$ – emission factor for $CO_2$ (kg $CO_2$/MJ)*
*$Q_z^d$ – net calorific value of fuel (MJ/kg ($m^3$))*
*$C^d$ – carbon content in fuel (%)*
*$M_{CO2}$ – molecule weight for $CO_2$ – 44. 0098 (g/mcl)*
*$M_C$ – molecule weight for C – 12.011 (g/mcl)*

**Table 3.18 Characteristics of methane obtained from landfill gas and estimated $CO_2$ emission factors**

| Amount of methane in landfill gas (%) | Default carbon content in working mass of methane ($C^d$) % | NCV of methane ($Q_z^d$) TJ/1000$m^3$ | Oxidation factor (p) | Natural gas density (ρ) t/1000$m^3$ | Emission factor with oxidation factor (EF $CO_2$) kg/GJ |
|---|---|---|---|---|---|
| 50% | 74.867543% | 35.88 | 0.995 | 0.6687 | 50.870474 |

Sludge gas

The $CO_2$ emission factor estimated below is estimated for pure methane that is obtained from collected sludge gas.

As wastewater treatment plant was not able to provide the information of carbon content percentage in working mass of fuel a constant carbon content in methane was used estimated on moll mass of components. Following equation was used for calculations:

$$C^d = \frac{M_C}{(M_C + M_H)} \times 100$$

*where:*
*$C^d$ – carbon content in fuel (%)*
*Mc – molecule weight for C – 12011 (g/mcl)*
*$M_H$ – H molecule weight (1.008 g/mcl)*
*100 – estimation of percentage*

For calculation of $CO_2$ emission factor of methane obtained from sludge gas the same equation as for natural gas was used. NCV numbers of methane obtained from sludge gas that is combusted with energy recovery for all years are obtained from wastewater treatment plant (Table 3.19).

**Table 3.19 Characteristics of methane obtained from sludge gas and estimated $CO_2$ emission factors**

| Amount of methane in sludge gas (%) | Default carbon content in working mass of methane ($C^d$) % | NCV of methane ($Q_z^d$) TJ/1000$m^3$ | Oxidation factor (p) | Natural gas density (ρ) t/1000$m^3$ | Emission factor with oxidation factor (EF $CO_2$) kg/GJ |
|---|---|---|---|---|---|
| 56-65% | 74.867543% | 35.88 | 0.995 | 0.6687 | 50.870474 |

### $SO_2$ emission factors

$SO_2$ emissions factors were calculated by equation taken from EMEP/EEA 2013 and were calculated by national expert considering physical characterizations of types of fuels used in Latvia and national and international legislation. Percentage amount of sulphur content in used fuels is taken from national database "2-AIR" where polluters report the sulphur content data for certain types of fuels (Annex A.3.1).

Emission factors for $SO_2$ are calculated by using following equation:

$$2 \times \left(\frac{s}{100}\right) \times \frac{1}{Q} \times 10^6 \times \left(\frac{100-r}{100}\right) \times \left(\frac{100-n}{100}\right)$$

*where:*
*EF – emission Factor (kg/TJ)*
*2 – $SO_2$ / S (kg/kg)*
*s – sulphur content in fuel (%)*
*r – retention of sulphur in ash (%)*
*Q – net calorific value (TJ/kt)*
*$10^6$ – (unit) conversion factor*
*n – efficiency of abatement technology and/or reduction efficiency (%)*

### Other emission factors

The default $CH_4$ and $N_2O$ emission factors used in estimation of emission were taken from 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.2.

Emission factors for $NO_x$, NMVOC and CO were taken from EMEP/EEA 2013, 1.A.1 Energy industries, Table 3-2 (coal, coke), Table 3-3 (peat, peat briquettes), Table 3-4 (natural gas, LPG, sludge gas), Table 3-5 (RFO), Table 3-6 (liquid fuels, including biodiesel). Emission factors used for 2015 Submission are listed in Table 3.20 below.

**Table 3.20 $CH_4$, $N_2O$, NOx, CO, NMVOC emission factors used in CRF 1.A.1. Energy Industries (kt/PJ)**

| | $CH_4$ | $N_2O$ | $NO_x$ | NMVOC | CO |
|---|---|---|---|---|---|
| Diesel oil | 0.003 | 0.0006 | 0.065 | 0.0008 | 0.0162 |
| RFO | 0.003 | 0.0006 | 0.142 | 0.0023 | 0.0151 |
| LPG | 0.001 | 0.0001 | 0.089 | 0.0026 | 0.039 |
| Jet fuel | 0.003 | 0.0006 | 0.065 | 0.0008 | 0.0162 |
| Other kerosene | 0.003 | 0.0006 | 0.065 | 0.0008 | 0.0162 |
| Other liquid | 0.003 | 0.0006 | 0.065 | 0.0008 | 0.0162 |
| Shale oil | 0.003 | 0.0006 | 0.065 | 0.0008 | 0.0162 |
| Coal | 0.001 | 0.0015 | 0.209 | 0.001 | 0.0087 |
| Coke | 0.001 | 0.0015 | 0.209 | 0.001 | 0.0087 |
| Peat briquettes | 0.001 | 0.0015 | 0.247 | 0.0014 | 0.0087 |
| Peat | 0.001 | 0.0015 | 0.247 | 0.0014 | 0.0087 |
| Natural gas | 0.001 | 0.0001 | 0.089 | 0.0026 | 0.039 |
| Wood | 0.030 | 0.0040 | 0.081 | 0.00731 | 0.09 |
| $CH_4$ from sludge gas | 0.001 | 0.0001 | 0.089 | 0.0026 | 0.039 |
| Landfill gas | 0.001 | 0.0001 | 0.089 | 0.0026 | 0.039 |
| Other biogas | 0.001 | 0.0001 | 0.089 | 0.0026 | 0.039 |
| Biodiesel | 0.003 | 0.0006 | 0.065 | 0.0008 | 0.0162 |
| Straws | 0.030 | 0.0040 | 0.081 | 0.00731 | 0.09 |
| Waste oils | 0.030 | 0.0040 | 0.065 | 0.0008 | 0.0162 |

*Activity data*

Mainly emissions from fuel combustion are calculated using fuel consumption data from the national Energy Balance, prepared by CSB. In previous submissions the Annual Questionnaires sent to EUROSTAT were used, but after an internal third party review in 2014 an expert's conclusion was to use Energy Balance, if possible, to ensure more precise data. As in the EUROSTAT tables fuel consumption mainly is in natural units (kt, millions $m^3$) therefore net calorific values provided by CSB were used to calculate fuel consumption into terajoules. However, there were differences between Annual Questionnaires' and Energy Balance data due to rounding and conversion of units therefore it was decided to use Energy Balance data with accuracy up to 1 TJ (instead of Annual Questionnaire accuracy 1 kt). Data on fuel consumption in CRF 1.A.1 sector are presented in Annex A.3.1 , Table 1.

The CSB data collection system is based on detailed compulsory survey 2-EK (annual). Form 2-EK "Survey on acquisition and consumption of energy resources" is collected from about 6000 enterprises and organizations (with all kind of economic activity) that are included in the lists of suppliers of statistical information.

Approximately 6000 respondents were surveyed - all enterprises of the local and public administration employing 10 or more persons, other enterprises employing 80 and more persons, as well as enterprises with turnovers equal or more than 4 mln euro, and other enterprises that CSB considers to be significant enough to include in the energy balance, for example, with large imports of briquettes, coal and oil products. Enterprises and organizations that are not included in the above mentioned selection were surveyed by the random sampling and afterwards the acquired results were extrapolated. 2–EK represents the basic tool for creating energy balances at a country level.

The amounts of methane from landfill gas combusted are taken from Waste expert, therefore are consistent with numbers of recovered amounts of landfill gas in Waste sector. The amounts of methane from sludge gas combusted are consistent with numbers of gas, recovered from Wastewater handling sector.

In Figure 3.15 there can be seen fuel consumption by fuel types in 1990-2014 in Energy Industries sector. The largest amounts of fuel types consumed are gaseous fuels in the whole time series and liquid fuels in the beginning of 1990s. The amounts of biomass consumed are slightly increasing, while the consumption of solid fuels and peat has sharply decreased.

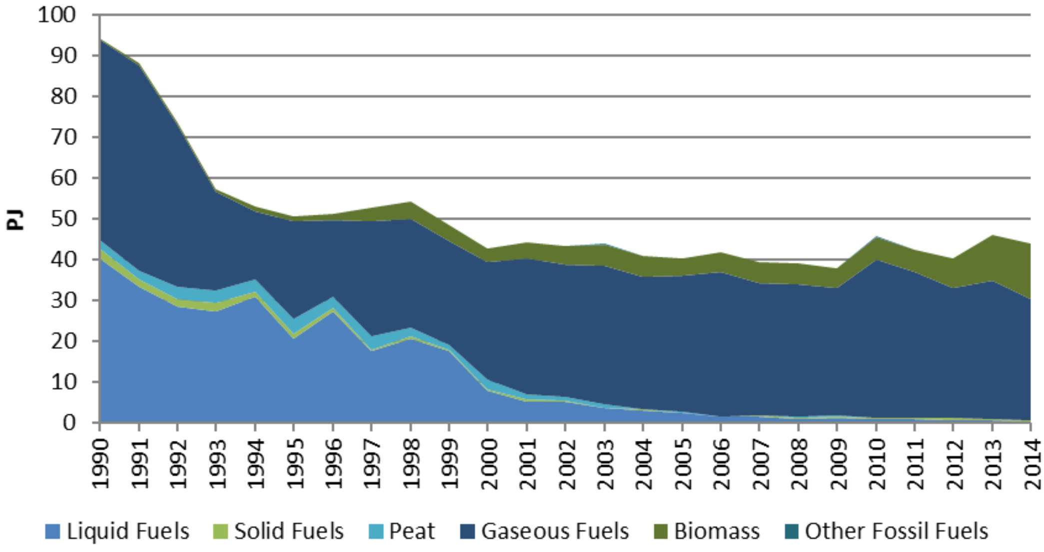


**Figure 3.15 Fuel consumption in Energy Industries (CRF 1.A.1) for 1990-2014 (PJ)**

The biggest decrease in time period 1990–2014 for the two sub-sectors of 1.A.1 Energy industries sector was for liquid fuel due to significant decrease of fuel consumption in 1.A.1.a subsector by 99.9%. It is explained with fuel switching processes when liquid fuels were switched to cheaper fuels. Also a stronger legislation contributed fuel switch to the type of fuels with lower level of emissions. It also explains why consumption of solid fuels decreased. However, in 2007-2013 the consumption of solid fuels increased that is explained with the increase of coal consumption in CRF 1.A.1.a subsector by 304% in 2006-2013. The increase of solid fuel consumption was promoted by increase of oil price in world when coal combustion became cheaper than combustion of residual fuel oil, diesel oil and natural gas. However, in 2013-2014 the consumption of coal in CRF 1.A.1.a reduced by 58.7%.

Consumption of biomass fuel has almost 30-fold increase in 1990–2014. Solid biomass is a local fuel and has lower costs therefore liquid and solid fuels were replaced with biomass and natural gas.

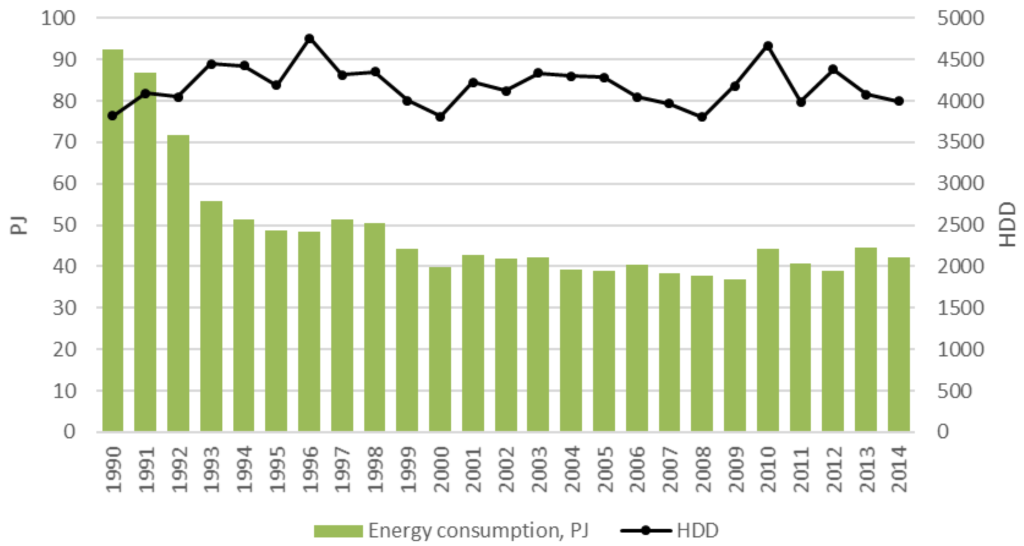


**Figure 3.16 Fuel consumption in Main activity electricity and heat production (CRF 1.A.1.a) and heating degree days in Latvia**

As it can be seen in Figure 3.16 the fuel consumption in 1.A.1.a sector can be related with the heating degree days with an exception of 1990s when Soviet Union collapsed and reorganizations took place in Latvia. However, for time period from 1997 to 2002 there can be seen that in years where energy consumption reduced, the HDD were also reduced. Years 2006-2008 had quite high average temperature therefore the fuel consumption of combined heat plants and heat plants for heat production decreased as there was limited need for heat production. In 2009-2010 the average temperature was lower and the use of fuel consumption increased. However, in year 2011 the fuel consumption decreased because of a relatively warm winter, and in year 2012 the consumption of fuel continued to decrease despite the fall of average temperature (hence the decrease in HDDs), which could be explained with better heat insulation in houses therefore less heat needed to be produced. In 2013 the fuel consumption increased, however, HDD were less than in 2012, while in 2014 it decreased, although the number of HDDs decreased.

#### 3.2.4.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty in activity data of fuel combustion in 1.A.1 sector is ±2% in 2014. CSB gives approximately 2% statistical sample error for statistical data. According to CSB, as data are obtained using information given by respondents, this number is a variation coefficient which characterizes selection of respondents. Total variation coefficient for energy balance is within 2-3%. In Latvia all fossil fuels (oil, natural gas and coal) are imported and import and export statistics are fairly accurate.

Uncertainty of activity data for solid biomass combustion was assigned as 5% because biomass activity data were collected by CSB with questionnaires sent by enterprises consumed biomass. Also, according to 2006 IPCC Guidelines, Volume 2, Chapter 1, pg. 1.19, biomass data are generally more uncertain than other data in national energy statistics, because a large fraction of the biomass may be part of the informal economy, and the trade in these types of fuels is frequently not registered in the national energy statistics and balances. That was a reason for higher uncertainty for biomass than for other fuel types. Uncertainty of sludge gas stationary combusted in enterprises covered by 1.A.1 Energy Industries sector was assumed rather low – 2% because the combusted fuel amount is obtained directly from wastewater treatment plant that has precise measurement equipment for accounting of combusted fuel. Still the methane percentage amount in combusted sludge gas is given approximately, therefore final uncertainty of combusted sludge gas is assumed as 5%. The same applies to landfill gas.

$CO_2$ emission factor was estimated according physical characterization of used fuels in country basing on average NCV reported by fuel consumers and carbon content, hence the uncertainty for liquid fuels was assigned as quite low – about 10%. As emission factors for solid fuels were taken from 2006 IPCC Guidelines, the uncertainty was assumed 20%. Emission factor uncertainty for peat and peat briquettes was assumed 10% because peat emission factor is country specific. $CO_2$ emission factor for natural gas was assumed rather low – as 5% because annual plant specific fuel data is used to estimate emission factor.

$CH_4$ and $N_2O$ emission factors used in estimation of emissions were taken according to 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.12., which provides the range of default values for uncertainties. The uncertainty both for $CH_4$ and $N_2O$ EFs of 50% was assigned similarly as in previous submissions – 50%.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. Emissions from all sectors are estimated or reported as not occurring / not applicable, therefore there are no "not estimated" sectors.

#### 3.2.4.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the Energy sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

All documentation and information received for inventory purposes are archived in FTP folder. All findings are documented by using check-lists, available on Regulations of the Cabinet of Ministers No. 217 adopted on 27 March 2012 "The National Inventory System of Greenhouse Gas Emission Units".

*Activity data verification*

All sources of energy data are presented in the corresponding NIR chapter (3.2.4.2 Methodological issues) as well as disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1. Data completeness has been explained in the previous subchapter.

Activity data have been checked at the data provider – Central Statistical Bureau, which has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data have been received, the sectoral expert responsible for the emission estimation and reporting are comparing all data changes with the previous inventory, and all changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

All activity data used in Sectoral Approach are also compared with activity data used in Reference Approach estimations. All significant differences (±5%) are explained in the corresponding subchapter.

*Emission factor verification*

For country-specific $CO_2$ emission factors, the sources of the calorific values, carbon content and oxidation factors, as well as these values are provided in 3.2.4.2 Methodological issues.

Country specific $CO_2$ values for year are compared with default ones available on 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.2. Whether country specific $CO_2$ emission factor is or is not in the confidence interval can be seen in Table 3.21.

**Table 3.21 Comparison of country specific and 2006 IPCC default $CO_2$ emission factor values (kt/PJ)**

| | Lower | CS | Upper | EU ETS |
|---|---|---|---|---|
| **Gasoline** | 67.50 | 71.18 | 73.00 | |
| **Diesel oil** | 72.60 | 74.00 | 74.80 | 74.75 |

| | Lower | CS | Upper | EU ETS |
|---|---|---|---|---|
| **RFO** | 75.50 | 76.59 | 78.80 | 77.36 |
| **LPG** | 61.60 | 62.44 | 65.60 | 62.75 |
| **Jet fuel** | 69.70 | 71.51 | 74.40 | |
| **Other kerosene** | 70.80 | 71.50 | 73.70 | |
| **Other liquid** | 72.20 | 72.59 | 74.40 | |
| **Shale oil** | 67.80 | 76.35 | 79.20 | 74.75 |
| **Peat** | 100.00 | 103.87 | 108.00 | 105.99 |
| **Natural gas** | 54.30 | 54.26 | 58.30 | 55.44 |
| **Wood** | 95.00 | 107.78 | 132.00 | |
| **Sludge gas** | 46.20 | 50.87 | 66.00 | |
| **Landfill gas** | 46.20 | 50.87 | 66.00 | |
| **Other biogas** | 46.20 | 50.87 | 66.00 | |

Only natural gas country specific $CO_2$ emission factor is outside of confidence interval given by 2006 IPCC Guidelines. Main reasons are different carbon content in fuel, as well as different NCVs.

*Emission verification:*

To verify the $CO_2$ emissions, logical mistakes are checked by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogical changes in the activity data and emissions. The emissions for indirect GHGs in the database are cross-checked with emissions reported within Convention on Long-range Transboundary Air Pollution (CLRTAP) for verification purposes.

$CO_2$ emissions are compared with emissions in Reference Approach estimations, and all significant differences (±5%) are explained in the corresponding subchapter.

#### 3.2.4.5 Category-specific recalculations

Recalculations have been done in CRF 1.A.1.a sector due to activity data corrections, therefore GHG emissions as well as indirect GHGs are recalculated. Regarding indirect GHGs, the EFs for NOx in 1A1a sector have been revised. For $SO_2$ EFs have been revised in every stationary combustion sector.

#### 3.2.4.6 Category-specific planned improvements

It is planned to update $CO_2$ EFs for most widely used fuels in Latvia, update data for offroad installations (detailed fuel use, facilities) and estimate life cycle of lubricants and used oils.

### 3.2.5 Manufacturing Industries and Construction (CRF 1.A.2)

#### 3.2.5.1 Category description

CRF 1.A.2 Manufacturing industries and construction sector includes emissions from fuel combustion in combustion installations for industrial production including emissions from off–road. CRF 1.A.2 sector also includes the emissions from on-site use of fuel in the industrial production facilities (autoproducers) – these emissions are reported under particular sub-sectors of CRF 1.A.2 according to 2006 IPCC Guidelines.

According to 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.1., emissions arising from off-road and other mobile machinery in industry should be broken out as a separate subcategory. These emissions are calculated together from all gasoline use in particular subsectors (Chemicals, Wood and wood products, Construction) within CRF 1.A.2. It also ensures the consistency between CLRTAP and UNFCCC data.

In Submission 2016, the CRF subsector CRF 1.A.2 Manufacturing industries was split into subsectors which are in line with 2006 IPCC Guidelines/CRF Reporter structure:

- 1.A.2.a Iron and steel;
- 1.A.2.b Non-ferrous metals;
- 1.A.2.c Chemicals;
- 1.A.2.d Pulp, paper and print;
- 1.A.2.e Food processing, beverages and tobacco;
- 1.A.2.f Non-metallic minerals;
- 1.A.2.g Other:
    - 1.A.2.g.i Manufacturing of machinery;
    - 1.A.2.g.ii Manufacturing of transport equipment;
    - 1.A.2.g.iii Mining (excluding fuels) and quarrying;
    - 1.A.2.g.iv Wood and wood products;
    - 1.A.2.g.v Construction;
    - 1.A.2.g.vi Textile and leather;
    - 1.A.2.g.vii Off-road vehicles and other machinery;
    - 1.A.2.g.viii Other.

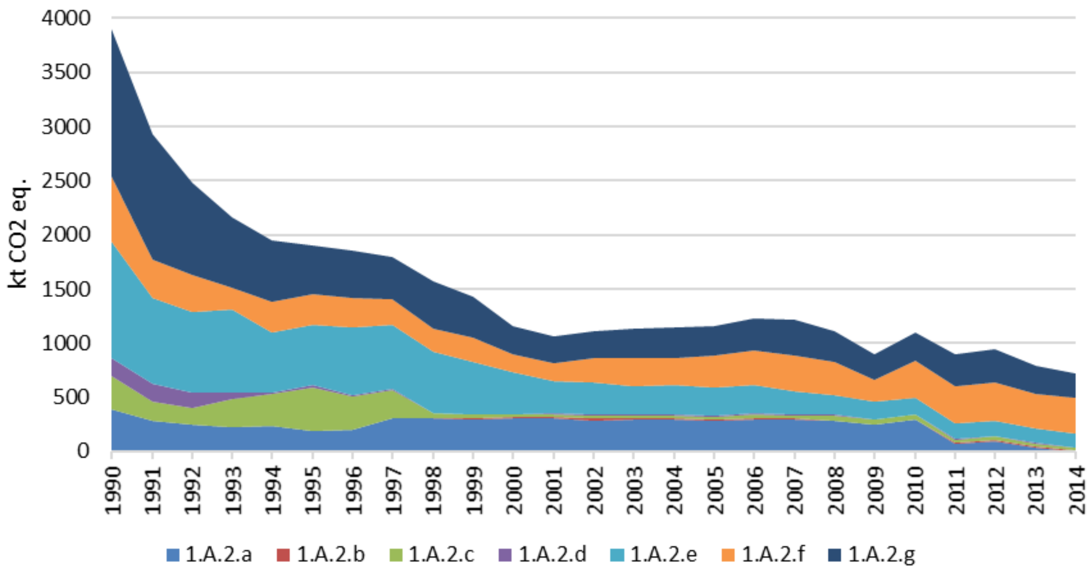


**Figure 3.17 GHG emissions in CRF 1.A.2. Manufacturing industries and Construction by subsectors (kt $CO_2$ eq.)**

In Figure 3.17, there can be seen the distribution of GHG emissions in CRF 1.A.2 sector. The largest part of emissions contributes to CRF 1.A.2.f Non-metallic minerals (45.1% in 2014) and CRF 1.A.2.g Other (32.1%), where emissions from Machinery, Transport equipment, Mining and quarrying, Wood processing, Construction, Textiles, Offroads and Other products are produced. In CRF 1.A.2.e Food processing, beverages and tobacco 17.4% of 1.A.2 GHG emissions are produced in 2014. Such sectors as CRF 1.A.2.a Iron and Steel, 1.A.2.b Non-ferrous metals, 1.A.2.c Chemicals. 1.A.2.d Pulp, Paper and Print contributes to 0.1%, 0.5%, 4.0% and 0.8% from total 1.A.2 GHG emissions in 2014, accordingly.

**Table 3.22 Emissions from Manufacturing industries and construction (CRF 1.A.2) in 1990–2014 (kt)**

| | $CO_2$ | $CH_4$ | $N_2O$ | Aggregate GHGs ($CO_2$, $CH_4$, $N_2O$) | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|---|
| | kt | | | kt $CO_2$ eq. | kt | | | |
| **1990** | 3883.95 | 0.22 | 0.029 | 3898.20 | 17.58 | 19.16 | 3.14 | 24.33 |
| **1991** | 2924.64 | 0.12 | 0.019 | 2933.12 | 12.29 | 6.86 | 1.68 | 15.12 |
| **1992** | 2478.06 | 0.11 | 0.016 | 2485.61 | 10.47 | 6.61 | 1.51 | 13.96 |
| **1993** | 2148.02 | 0.13 | 0.021 | 2157.70 | 10.03 | 7.68 | 1.76 | 14.44 |
| **1994** | 1940.32 | 0.13 | 0.022 | 1950.07 | 9.59 | 6.12 | 1.62 | 15.67 |
| **1995** | 1892.17 | 0.14 | 0.022 | 1902.04 | 9.61 | 4.12 | 1.50 | 15.08 |
| **1996** | 1848.94 | 0.15 | 0.022 | 1859.31 | 9.35 | 5.63 | 1.71 | 14.68 |
| **1997** | 1789.75 | 0.15 | 0.022 | 1800.03 | 9.15 | 4.79 | 1.63 | 14.25 |
| **1998** | 1561.37 | 0.15 | 0.022 | 1571.73 | 7.65 | 4.80 | 1.68 | 11.02 |
| **1999** | 1413.35 | 0.14 | 0.021 | 1423.25 | 6.83 | 3.96 | 1.57 | 9.10 |
| **2000** | 1149.59 | 0.12 | 0.017 | 1157.74 | 4.87 | 3.29 | 1.36 | 4.70 |
| **2001** | 1050.07 | 0.16 | 0.022 | 1060.62 | 3.77 | 3.83 | 1.71 | 2.55 |
| **2002** | 1099.67 | 0.16 | 0.022 | 1110.08 | 3.62 | 3.99 | 1.66 | 2.07 |
| **2003** | 1118.65 | 0.15 | 0.020 | 1128.28 | 3.69 | 3.54 | 1.58 | 1.86 |
| **2004** | 1132.09 | 0.19 | 0.026 | 1144.48 | 3.73 | 5.05 | 2.08 | 1.42 |
| **2005** | 1138.69 | 0.22 | 0.031 | 1153.40 | 3.49 | 6.16 | 2.35 | 1.56 |
| **2006** | 1210.08 | 0.24 | 0.033 | 1225.76 | 3.92 | 7.09 | 2.65 | 1.79 |
| **2007** | 1205.25 | 0.20 | 0.029 | 1219.05 | 3.77 | 7.00 | 2.36 | 1.72 |
| **2008** | 1098.86 | 0.22 | 0.031 | 1113.56 | 3.39 | 7.18 | 2.44 | 1.38 |
| **2009** | 872.78 | 0.29 | 0.040 | 891.83 | 3.04 | 6.86 | 3.02 | 1.05 |
| **2010** | 1070.40 | 0.35 | 0.049 | 1093.75 | 3.20 | 7.12 | 3.36 | 0.99 |
| **2011** | 869.96 | 0.41 | 0.058 | 897.55 | 2.74 | 7.81 | 3.69 | 0.81 |
| **2012** | 914.14 | 0.47 | 0.066 | 945.51 | 3.06 | 8.89 | 4.24 | 0.94 |
| **2013** | 755.52 | 0.49 | 0.067 | 787.65 | 2.88 | 9.00 | 4.36 | 0.83 |
| **2014** | 685.67 | 0.55 | 0.075 | 721.97 | 2.82 | 10.03 | 4.89 | 0.89 |
| **Share of Energy total, 2014** | 10.5% | 4.4% | 20.4% | 10.4% | 9.5% | 7.9% | 22.6% | 22.4% |
| **2014 versus 2013** | -9.2% | 13.3% | 12.8% | -8.3% | -2.2% | 11.4% | 12.0% | 7.6% |
| **2014 versus 1990** | -82.3% | 152.3% | 156.2% | -81.5% | -84.0% | -47.7% | 55.8% | -96.3% |

Emissions from CRF 1.A.2 significantly decreased in 1990 to 2001, which can be explained with recession of Soviet Union and following reformations and reorganizations within Latvia after that. Since 2001, the emissions started to increase until 2006, because of development in national economy and industry, as well as growing demand of industrial production and increasing welfare of inhabitants (Table 3.22). Growth in GHG emissions in the given time period were caused by increased amounts of coal and natural gas consumed. Decrease of emissions in 2006-2008 were influenced by the features of national economy development when in-country industrial production already started to diminish due to increasing costs of the production and dominance of imported products. Crisis in national economy in the second part of 2008 also caused a significant decrease in total emissions. The increasing amounts of solid biomass consumption also caused a drop in $CO_2$ emissions. The crisis in national economy caused by global financial crisis in 2008-2009 influenced quite significant decrease of GHG emissions by 20%. The crisis and development of EU ETS influenced biomass consumption for 2008-2009 in 1.A.2 sector – its amounts were growing, while amounts of almost all other fuels decreased. In 2010-2014 the emissions are fluctuating mainly due to reconstructions in 2011-2012 in the largest steel producer "Liepājas Metalurgs". As it replaced its furnace to electric one, the emissions decreased, however, in 2013 due to several reasons it initiated bankruptcy, therefore the amounts of production decreased significantly afterwards.

Due to the essential increase of biomass consumption non-$CO_2$ emissions increased in 2009-2014: $CH_4$ emissions increased by 93%, while $N_2O$ emissions increased by 89%.

Also indirect GHG emissions from CRF 1.A.2 sector were estimated. In this sector almost all indirect emissions have decreased: NOx emissions have decreased by 84.0%, CO emissions – by 47.7%, and $SO_2$ emissions have a decrease by 96.3% in 1990–2014. The decrease in emissions is explained with fuel switching to natural gas and biomass from what sulphur dioxide emissions are not emitted, and there are less NOx and CO emissions from these fuels comparing with solid and liquid fuels. However, NMVOC emissions have an increasing trend and have increased by 55.8% since 1990 due to very high emission factors for biomass compared to other fuels.

#### 3.2.5.2 Methodological issues

*Methods*

2006 IPCC Guidelines' Tier 2 method was used to estimate $CO_2$ emissions from fuel combustion as country specific parameters were used to estimate $CO_2$ emission factor. However, for some fuels there are no country-specific emission factors, therefore 2006 IPCC Tier 1 method using default emission factors was used. 2006 IPCC Guidelines' Tier 1 method was used to calculate $CH_4$ and $N_2O$ emissions from the CRF 1.A.2 sector.

Calculation of all emissions from fuel combustion is done with Excel databases developed by the experts from LEGMC.

The general method for emission data preparation was used:

$$Em = EF \times B_q$$

*where:*
*Em – total emissions (kt)*
*EF – estimated or default emission factor (t/TJ)*
*$B_q$ – amount of fuel in thermal units (TJ)*

*Emission factors and other parameters*

The main sources for emission factors are:

- National studies for country specific parameters and emission factors;
- Data from only natural gas supplier company of natural gas physical characteristics;
- EU ETS reports (for used tires and municipal waste);
- IPCC 2006 Guidelines;
- EMEP/EEA 2013.

Country specific emission factors were used to calculate carbon dioxide ($CO_2$) and sulphur dioxide ($SO_2$) emissions.

**$CO_2$ emission factors**

$CO_2$ emission factors for CRF 1.A.2 Manufacturing Industries and Construction sector are estimated with the same equations and using the same method as for CRF 1.A.1 Energy industries sector with the exception for industrial waste and municipal waste that are not combusted in CRF 1.A.1 sector.

For some fuels default $CO_2$ emission factors from 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.3, were taken due to unavailability of country specific data:

- other liquid fuels – 73.3 kt/PJ;
- coal – 94.6 kt/PJ;
- coke – 107 kt/PJ;
- anthracite – 98.3 kt/PJ;
- oil shale – 107 kt/PJ;
- petroleum coke – 97.5 kt/PJ
- peat briquettes – 97.5 kt/PJ;
- biodiesel – 70.8 kt/PJ;
- straws – 100 kt/PJ;
- waste oils – 73.3 kt/PJ.

Municipal waste

$CO_2$ emission factors of municipal waste combusted in cement production plants are taken from plant's annual GHG report within EU ETS for 2008-2014. This $CO_2$ emission factors are estimated at the plant by using plant specific data about combustion installation as well as net calorific value and carbon content measured and obtained in the plant laboratory. 2006 IPCC Guidelines state to separate non-biomass and biomass parts of the municipal waste. It has been done in Submission 2016 as follows: $CO_2$ emissions to be reported to EU ETS have been taken from 2008-2014 for non-biomass part, because for EU ETS only non-biomass $CO_2$ emissions have to be reported. The emission factors given in the reports are for whole emissions and it is possible to calculate the emission factor for non-biomass fraction. The emission factors for total $CO_2$ emissions and for non-biomass fraction are provided in Table 3.23.

**Table 3.23 $CO_2$ emission factors, carbon content and NCV for municipal waste by waste types (kt/PJ)**

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| | **Total $CO_2$ EF, kt/PJ** | | | | | | |
| ***Ecofuel 1*** | 85.19 | 82.81 | | | | | 80.43 |
| ***Ecofuel 2*** | | 120.95 | 82.69 | 113.22 | 95.24 | 85.98 | 88.517 |
| | **Fossil $CO_2$ EF, kt/PJ** | | | | | | |
| ***Ecofuel 1*** | 44.16 | 43.03 | | | | | 38.524 |
| ***Ecofuel 2*** | | 71.01 | 35.11 | 27.99 | 32.42 | 38.69 | 44.966 |
| | **C content, %** | | | | | | |
| ***Ecofuel 1*** | 20.206 | 20.275 | | | | | 23.583 |
| ***Ecofuel 2*** | | 33.009 | 22.567 | 30.9 | 25.993 | 23.465 | 24.158 |
| | **NCV, TJ/kt** | | | | | | |
| ***Ecofuel 1*** | 22.779 | 23.514 | | | | | 19.352 |
| ***Ecofuel 2*** | | 17.416 | 19.594 | 18.232 | 16.852 | 17.615 | 31.46 |
| | **Biomass content, %** | | | | | | |

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| ***Ecofuel 1*** | 48.16% | 48.04% | | | | | 55.42% |
| ***Ecofuel 2*** | | 58.70% | 57.54% | 75.28% | 65.96% | 41.33% | 49.20% |

For estimating biomass emissions the following equation was used:

$$E_{biomass} = E_{total} - E_{non-biomass}$$

*where:*
$E_{biomass}$ *– $CO_2$ emissions from biomass fraction (kt)*
$E_{total}$ *– total $CO_2$ emissions (kt)*
$E_{non-biomass}$ *- $CO_2$ emissions from biomass fraction (kt)*

The calculated results for total $CO_2$ emissions from municipal waste, as well as from biomass and non-biomass fraction can be found in Table 3.24.

**Table 3.24 $CO_2$ emissions from municipal waste non-biomass and biomass fractions by waste types in 2008-2014**

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| | **Fossil $CO_2$ emissions, Mg** | | | | | | |
| ***Ecofuel 1*** | 6856 | 2284.5 | | | | | 77069 |
| ***Ecofuel 2*** | | 304.63 | 26440 | 37606 | 54948 | 60808 | 2033.8 |
| | **Biomass $CO_2$ emissions, Mg** | | | | | | |
| ***Ecofuel 1*** | 6369.7 | 2112.2 | | | | | 95801 |
| ***Ecofuel 2*** | | 214.25 | 35835 | 114499 | 106458 | 74321 | 1969.8 |
| | **Total $CO_2$ emissions, Mg** | | | | | | |
| ***Ecofuel 1*** | 13226 | 4396.7 | | | | | 172870 |
| ***Ecofuel 2*** | | 518.88 | 62275 | 152105 | 161406 | 135129 | 4003.6 |

<u>Industrial waste</u>

Emission factors for $CO_2$ emission estimation for industrial waste – used tires, neutralised polluted soil, waste wood, fluffy tyre, wood processing residues and shredded rubber – combusted in CRF 1.A.2.f Non-metallic minerals (cement production) for years 1999–2014 are taken from GHG emission reports that plant submitted under ETS (Table 3.25). These $CO_2$ emission factors are estimated at the plant by using plant specific data about combustion installation as well as net calorific value and carbon content measured and obtained in the plant laboratory. Also for this fuel type biomass and non-biomass emissions have been calculated, as this fuel contains biomass.

**Table 3.25 $CO_2$ emission factors, carbon content and NCV for industrial waste**

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Total $CO_2$ EF, kt/PJ** | | | | | | | | | | | | | | | |
| **Used tyres** | 79.44 | 79.44 | 79.44 | 79.44 | 79.44 | 79.44 | 79.44 | 79.44 | 79.44 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| **NPS** | | | | | | | | | | | | | | 79.43 | 80.602 | 85.034 |
| **Waste wood** | | | | | | | | | | | | 117.6 | | | | |
| **Fluffy tyres** | | | | | | | | | | | | | 81.13 | 81.13 | 87.01 | |
| **Wood processing residues** | | | | | | | | | | | | | 135.3 | 130.35 | | |
| **Shredded** | | | | | | | | | | | | | | | 81.13 | |

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **rubber** | | | | | | | | | | | | | | | | |
| | **Fossil $CO_2$ EF, kt/PJ** | | | | | | | | | | | | | | | |
| **Used tyres** | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 | 60.9 |
| **NPS** | | | | | | | | | | | | | | 66.313 | 56.421 | 60.032 |
| **Waste wood** | | | | | | | | | | | | 15.88 | | | | |
| **Fluffy tyres** | | | | | | | | | | | | | 27.01 | 17.93 | 30.45 | |
| **Wood processing residues** | | | | | | | | | | | | | 37.58 | 41.47 | | |
| **Shredded rubber** | | | | | | | | | | | | | | | 41.22 | |
| | **C content, %** | | | | | | | | | | | | | | | |
| **Used tyres** | 23.046 | 23.046 | 23.046 | 23.046 | 23.046 | 23.046 | 21.68 | 21.68 | 21.680 | 23.198 | 23.198 | 23.198 | 23.198 | 23.198 | 23.198 | 23.198 |
| **NPS** | | | | | | | | | | | | | | 21.678 | 21.998 | 23.207 |
| **Waste wood** | | | | | | | | | | | | 32.095 | | | | |
| **Fluffy tyres** | | | | | | | | | | | | | 22.142 | 22.142 | 23.746 | |
| **Wood processing residues** | | | | | | | | | | | | | 36.926 | 35.575 | | |
| **Shredded rubber** | | | | | | | | | | | | | | | 22.142 | |
| | **NCV (TJ/kt)** | | | | | | | | | | | | | | | |
| **Used tyres** | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 | 26.21 |
| **NPS** | | | | | | | | | | | | | | 14.3 | 14.999 | 16.232 |
| **Waste wood** | | | | | | | | | | | | 13.182 | | | | |
| **Fluffy tyres** | | | | | | | | | | | | | 28.500 | 42.937 | 28.961 | |
| **Wood processing residues** | | | | | | | | | | | | | 12.569 | 12.114 | | |
| **Shredded rubber** | | | | | | | | | | | | | | | 31.315 | |
| | **Biomass content, %** | | | | | | | | | | | | | | | |
| **Used tyres** | 28% | 28% | 28% | 28% | 28% | 28% | 28% | 28% | 28% | 28% | 28% | 28% | 28% | 28% | 28% | 28% |
| **NPS** | | | | | | | | | | | | | | 17% | 30% | 29% |
| **Waste wood** | | | | | | | | | | | | 87% | | | | |
| **Fluffy tyres** | | | | | | | | | | | | | 67% | 78% | 65% | |
| **Wood processing residues** | | | | | | | | | | | | | 72% | 68% | | |
| **Shredded rubber** | | | | | | | | | | | | | | | 49% | |

For estimating biomass emissions, the above mentioned equation for municipal waste was used.

Since 2005 the cement production plant is participating in EU Emission trading scheme therefore estimated $CO_2$ EF is verified by accredited verifiers and approved by Regional Environmental Board.

**$SO_2$ emission factors**

$SO_2$ emission factors for all fuels, except industrial and municipal waste, in CRF 1.A.2 Manufacturing Industries and Construction sector are estimated with the same equations and using the same method as for CRF 1.A.1 Energy industries sector.

For industrial and municipal waste $SO_2$ emission factors are taken from EMEP/EEA 2013, Chapter 5.C.1.b, Table 3-1 (0.0047 kg/Mg) and Chapter 5.C.1.a, Table 3-1 (0.087 kg/Mg).

**Other emission factors**

List of other emission factors can be seen in Table 3.26.

The default $CH_4$ and $N_2O$ emission factors are taken from 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.3. Gasoline emission factors are used for $CH_4$ and $N_2O$ emission estimation from off-roads (2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Table 3.3.1.). As there is no information about distribution between 2-stroke and 4-stroke engines, it was assumed that 25% of consumed gasoline is combusted in 2-stroke engines, while 75% - in 4-stroke engines. Such assumption has been made, based on Danish data which are presented in EMEP/EEA 2013 for air pollutants' calculations.

$NO_x$, CO and NMVOC emission factors used in estimation of emission were taken from EMEP/EEA 2013, Chapter 1.A.2, Tables 3-2 to 3-5, with an exception of oil shale which has been taken from Estonian NIR 2015 as country specific. For industrial waste and municipal waste $NO_x$, CO and NMVOC emission factors are taken from EMEP/EEA 2013, Chapter 5.C.1.b, Table 3-1 and Chapter 5.C.1.a, Table 3-1 (Table 3.26).

**Table 3.26 $CH_4$, $N_2O$, NOx, NMVOC, CO emission factors (kt/PJ[18])**

| | | $CH_4$ | $N_2O$ | $NO_x$ | NMVOC | CO |
|---|---|---|---|---|---|---|
| **Gasoline** | **2-stroke** | 0.130 | 0.0004 | 2.765 | 242.197 | 620.793 |
| | **4-stroke** | 0.050 | 0.0020 | 7.117 | 17.602 | 770.368 |
| **Diesel oil** | | 0.003 | 0.0006 | 0.513 | 0.030 | 0.070 |
| **RFO** | | 0.003 | 0.0006 | 0.513 | 0.030 | 0.070 |
| **LPG** | | 0.001 | 0.0001 | 0.074 | 0.023 | 0.029 |
| **Jet fuel** | | 0.003 | 0.0006 | 0.513 | 0.030 | 0.070 |
| **Other kerosene** | | 0.003 | 0.0006 | 0.513 | 0.030 | 0.070 |
| **Other liquid** | | 0.003 | 0.0006 | 0.513 | 0.030 | 0.070 |
| **Petroleum coke** | | 0.003 | 0.0006 | 0.513 | 0.030 | 0.070 |
| **Waste oils** | | 0.030 | 0.0006 | 0.513 | 0.030 | 0.070 |
| **Shale oil** | | 0.003 | 0.0006 | 0.513 | 0.030 | 0.070 |
| **Coal** | | 0.000 | 0.0015 | 0.173 | 0.089 | 0.931 |
| **Coke** | | 0.001 | 0.0015 | 0.173 | 0.089 | 0.931 |
| **Anthracite** | | 0.001 | 0.0015 | 0.173 | 0.089 | 0.931 |
| **Oil shale** | | 0.001 | 0.0015 | 0.110 | 0.050 | 0.087 |
| **Peat briquettes** | | 0.001 | 0.0015 | 0.173 | 0.089 | 0.931 |
| **Peat** | | 0.002 | 0.0015 | 0.173 | 0.089 | 0.931 |
| **Natural gas** | | 0.001 | 0.0001 | 0.074 | 0.023 | 0.029 |
| **Wood** | | 0.030 | 0.0040 | 0.091 | 0.300 | 0.570 |
| **Other biogas** | | 0.001 | 0.0001 | 0.074 | 0.023 | 0.029 |
| **Biodiesel** | | 0.003 | 0.0006 | 0.513 | 0.030 | 0.070 |
| **Industrial waste (used tires)** | | 0.030 | 0.0040 | 0.870 | 7.400 | 0.070 |

[18] *For indirect GHGs for gasoline, industrial and municipal waste – kg/Mg*

| | $CH_4$ | $N_2O$ | $NO_x$ | NMVOC | CO |
|---|---|---|---|---|---|
| **Municipal waste** | 0.030 | 0.0040 | 1.071 | 0.0059 | 0.041 |
| **Waste oils** | 0.030 | 0.0040 | 0.513 | 0.030 | 0.070 |

There is a different approach regarding CRF 1.A.2.f *Non-metallic minerals* subsector and corresponding subsector under IPPU (CRF 2.A.1 *Cement production*). Until 2010 indirect GHG emissions under CRF 2.A.1 sector were calculated using EMEP/CORINAIR 2007 and EMEP/EEA 2009 methodology, but afterwards these emissions were automatically detected at plant site, and measurements are taken in the main chimney. However, as these values are measured directly in the chimney, there is no way to allocate emissions under Energy and IPPU sectors separately (there are both emissions from fuel combustion and technological processes). Regarding calculation of indirect GHGs, to avoid double counting, the following fuel types (used tyres, ecofuel, coal, natural gas consumed in "Cemex") are subtracted from Energy part (from CRF 1.A.2.f subsector) and their emissions can be considered as included elsewhere (CRF 2.A.1 sector under IPPU) in case of "Cemex". However, as "Cemex" is not the only company under CRF 1.A.2.f subsector, fuel consumption and emissions appear from other enterprises. As for GHGs, these emissions are taken from EU ETS reports ($CO_2$) reported by "Cemex" or calculated ($CH_4$, $N_2O$), therefore can be allocated under appropriate sectors.

*Activity data*

Mainly emissions from fuel combustion are calculated using fuel consumption data from the national Energy Balance, prepared by CSB. The data collection system for CRF 1.A.2 sector is the same as for CRF 1.A.1 sector. Data on fuel consumption in 1.A.2 sector are presented in Annex A.3.1.

Autoproducers data prepared by CSP are taken into account into the calculation of the emissions from CRF 1.A.2 sector according to 2006 IPCC Guidelines.

Only gasoline combustion is reported as off-roads in CRF 1.A.4 sector, except for 1A4c where approximate amounts of diesel are consumed in offroad installations.

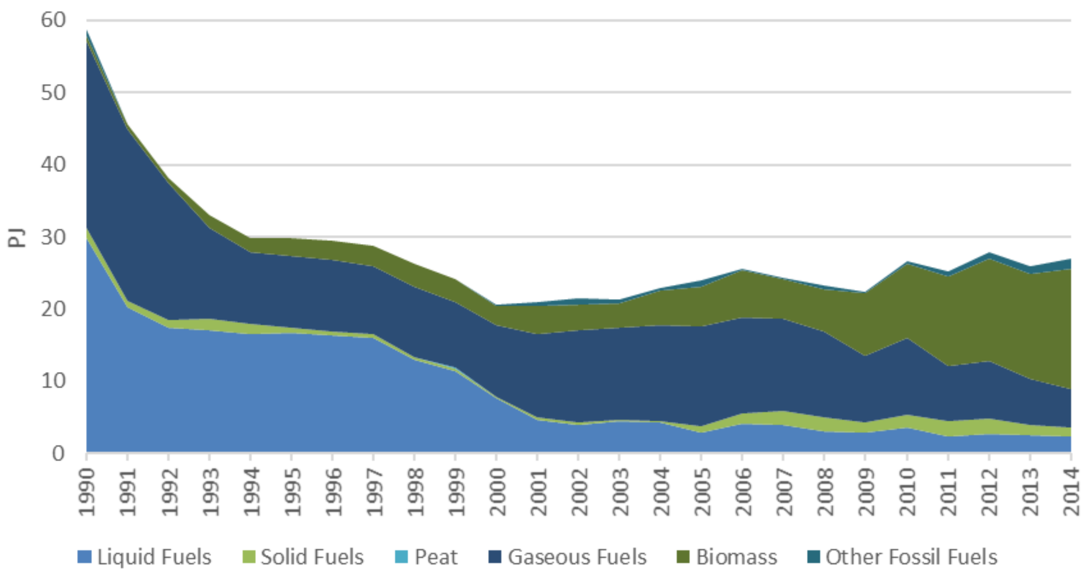


**Figure 3.18 Fuel consumption in Manufacturing industries and construction (CRF 1.A.2) for 1990-2014 (PJ)**

The most of fuel types with an exception of biomass and other fossil fuels have decreased in 1990-2014 (Figure 3.18). Liquid fuels have the biggest decrease in time period by 92%. It is explained with fuel switching processes when liquid fuels were replaced with other cheaper fuels. Also stronger legislation contributed fuel replacement to the type of fuels with lower level of emissions. Decrease of natural gas reflects the total decrease of industrial production if comparing with 1990.

The consumption of solid fuels (mainly coal) decreased in 1990-2004 with an exception of 1993-1994, mainly due to increased use of coal in Construction and Textiles and Leather sectors. Solid fuels consumption was growing rapidly by 7.5 times since 2004 until 2008 because of the growth in national economy, and decreased in 2009 by 32% due to global crisis. However, starting from 2009, the consumption of solid fuels grew by 58% until year 2012. The increase of solid fuel consumption was promoted by the increase of oil price overall the world when coal combustion was cheaper than combustion of residual fuel oil and diesel oil. The increase in Latvia is also explained with the development of mineral production sector – cement production – where coal is consumed. In 2012-2014 there can be seen a drop in solid fuel consumption – in Non-metallic minerals sector the consumption decreased by 34%, and in Iron and Steel sector by 100% because of bankruptcy of the largest steel producing company, which was mentioned in 3.2.5.2. Methodological issues.

After the crisis in the beginning of 1990s natural gas consumption steadily increased with some small exceptions due to fuel replacement processes and development of national economy.

Consumption of biomass fuel has increased very significantly – by 2.6 times in 1990–2014 with some fluctuations in 2000-2008. Lower costs of solid and liquid biomass, free and large availability of the fuel in-country as well as development of EU ETS were the main reasons for liquid and solid fuels' replacement with biomass and natural gas.

Consumption of used tires and municipal waste in Mineral production (information taken from „CEMEX", the only company which combusts used tires and municipal waste for energy purposes) reported as other fossil fuels had a 46-fold increase in 1999-2014, and continue to increase year by year. Comparing with 2010, the consumption of waste has increased by 2.1 times in 2014. The increase was influenced by intensified cement production that was caused by increased demand of construction materials and sharp development of construction sector. In other fossil fuels also used oils are reported, and the amounts of this fuel are fluctuating over years with a decreasing trend in recent years.

#### 3.2.5.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty in activity data of fuel combustion in 1.A.2 sector is ±2% in 2014. CSB gives approximately 2% statistical sample error for statistical data. According to CSB, as data are obtained using information given by respondents, this number is a variation coefficient which characterizes selection of respondents. Total variation coefficient for energy balance is within 2-3%. In Latvia all fossil fuels (oil, natural gas and coal) are imported and import and export statistics are fairly accurate.

Uncertainty of activity data for solid biomass combustion was assigned as 5% because biomass activity data were collected by CSB with questionnaires sent by enterprises consumed biomass. Also, according to 2006 IPCC Guidelines, Volume 2, Chapter 1, pg. 1.19, biomass data are generally more uncertain than other data in national energy statistics, because a large fraction of the biomass may be part of the informal economy, and the trade in these type of fuels is frequently not registered in the national energy statistics and balances.

Uncertainty of other fuels consumption – municipal and industrial waste used in mineral production is assumed also low – 2% as the activity data is obtained from only one producer within EU ETS therefore the data is verified by accredited verifier and Regional Environmental Board.

$CO_2$ emission factor was estimated according physical characterization of used fuels in country basing on average NCV reported by fuel consumers and carbon content so uncertainty for liquid fuels was assigned as quite low about 10%. The same uncertainty level was assigned for peat. However, for combustion of solid fuels and other fossil fuels (waste oils) the uncertainty of $CO_2$ emission factor was assigned higher to 20% because $CO_2$ emission factor of anthracite, coal and coke was taken from 2006 IPCC Guidelines. $CO_2$ emission factor for natural gas was assumed rather low as 5% because plant specific fuel data is used to estimate emission factor.

$CO_2$ emission factors for industrial and municipal waste are assumed as 2% as were determined in accredited laboratory of cement production company.

$CH_4$ and $N_2O$ emission factor used in estimation of emissions was taken according to 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.12., which provides the range of default values for uncertainties. The uncertainty both for $CH_4$ and $N_2O$ EFs was assigned as uncertainties used in previous submissions – 50%.

Time series of the estimated emissions are consistent and complete because the same methodology emission factors and data sources are used for sectors for all years in time series. Emissions from all sectors are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

#### 3.2.5.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the Energy sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

All documentation and information received for inventory purposes are archived in FTP folder. All findings are documented by using check-lists, available on Regulations of the Cabinet of Ministers No. 217 adopted on 27 March 2012 "The National Inventory System of Greenhouse Gas Emission Units".

*Activity data verification*

All sources of energy data are presented in the corresponding NIR chapter Methodological issues.

as well as disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1. Data completeness has been explained in the previous subchapter.

Activity data have been checked at the data provider – Central Statistical Bureau, which has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data have been received, the sectoral expert responsible for the emission estimation and reporting are comparing all data changes with the previous inventory, and all changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

All activity data used in Sectoral Approach are also compared with activity data used in Reference Approach estimations. All significant differences (±5%) are explained in the corresponding subchapter.

*Emission factor verification*

For country-specific $CO_2$ emission factors, the sources of the calorific values, carbon content and oxidation factors, as well as these values are provided in corresponding NIR chapter Methodological issues.

Country specific $CO_2$ values for year are compared with default ones available on 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.2. Whether country specific $CO_2$ emission factor is or is not in the confidence interval can be seen in Table 3.27.

**Table 3.27 Comparison of country specific and 2006 IPCC default $CO_2$ emission factor values (kt/PJ)**

| | Lower | CS | Upper | EU ETS |
|---|---|---|---|---|
| **Gasoline** | 67.50 | 71.18 | 73.00 | |
| **Diesel oil** | 72.60 | 74.00 | 74.80 | 74.75 |
| **RFO** | 75.50 | 76.59 | 78.80 | 77.36 |
| **LPG** | 61.60 | 62.44 | 65.60 | 62.75 |
| **Jet fuel** | 69.70 | 71.51 | 74.40 | |
| **Other kerosene** | 70.80 | 71.50 | 73.70 | |
| **Other liquid** | 72.20 | 72.59 | 74.40 | |
| **Shale oil** | 67.80 | 76.35 | 79.20 | 74.75 |
| **Peat** | 100.00 | 103.87 | 108.00 | 105.99 |
| **Natural gas** | 54.30 | 54.26 | 58.30 | 55.44 |
| **Wood** | 95.00 | 107.78 | 132.00 | |
| **Sludge gas** | 46.20 | 50.87 | 66.00 | |
| **Landfill gas** | 46.20 | 50.87 | 66.00 | |
| **Other biogas** | 46.20 | 50.87 | 66.00 | |

Only natural gas country specific $CO_2$ emission factor is outside of confidence interval given by 2006 IPCC Guidelines. Main reasons are different carbon content in fuel, as well as different NCVs.

*Emission verification:*

To verify the $CO_2$ emissions, logical mistakes are checked by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogical changes in the activity data and emissions. The emissions for indirect GHGs in the database are cross-checked with emissions reported within CLRTAP for verification purposes.

$CO_2$ emissions are compared with emissions in Reference Approach estimations, and all significant differences (±5%) are explained in the corresponding subchapter.

#### 3.2.5.5 Category-specific recalculations

Recalculations have been done in CRF 1.A.2.e, 1.A.2.f, 1.A.2.g sectors due to activity data corrections, therefore GHG emissions as well as indirect GHGs are recalculated. Regarding $SO_2$, EFs have been revised in every stationary combustion sector.

#### 3.2.5.6 Category-specific planned improvements

It is planned to update $CO_2$ EFs for most widely used fuels in Latvia and estimate life cycle of lubricants and used oils.

### 3.2.6 Transport (CRF 1.A.3)

#### 3.2.6.1 Category description

This section describes GHG emissions resulting from transport fuel combustion. In 2014, this source category was responsible for around 26.0% of total GHG emissions in Latvia, reaching 2952 kt (see Figure 3.19).

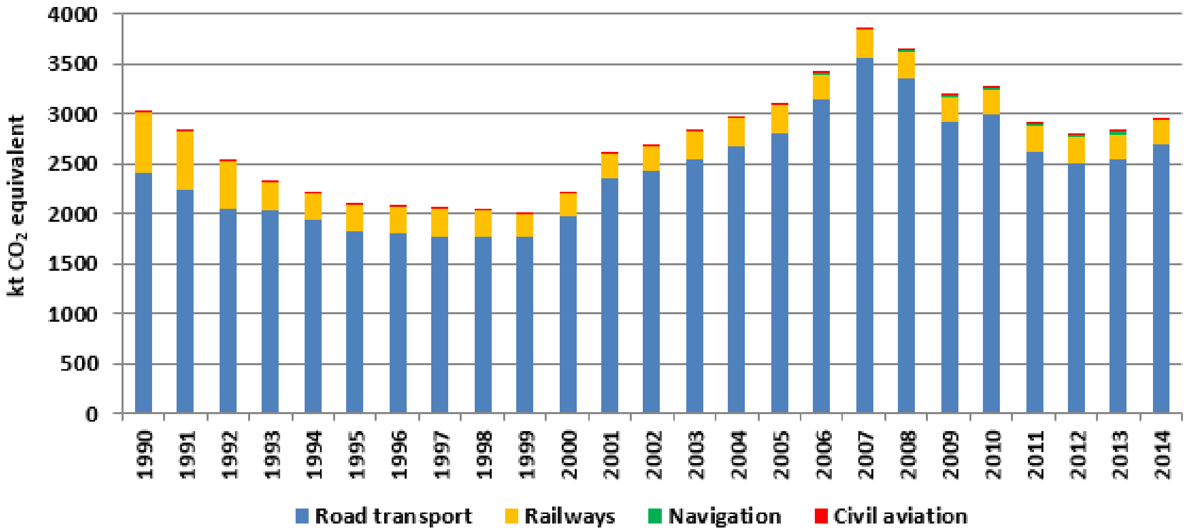


**Figure 3.19 GHG emissions development in transport 1990 – 2014 (kt $CO_2$ eq.)**

Emissions from Transport (CRF 1.A.3) include all domestic transport sectors: civil aviation, road transport, railways, domestic navigation and other mobile sources (which are not included in other sectors).

In 2014, total GHG emissions in the transport sector, compared to 1990 level, have decreased by 2.6%. The GHG emissions in 2014, compared to 2013, were by 4.3% higher.

The road transport constitutes a convincing majority of the total GHG emissions in the transport sector. In 2014, it gave around 91.3 % of total emissions but the next largest emission source is railway – 8.1 % (see Figure 3.20).

$CO_2$ emissions constitute nearly 97% of the total GHG emissions in the transport sector and they are key sources in road transport and railway as well (see Figure 3.21).

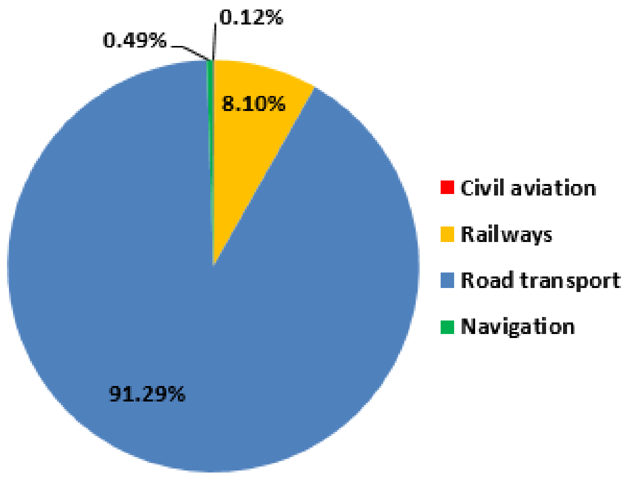


**Figure 3.20 GHG emissions in transport by sub-sectors in 2014**

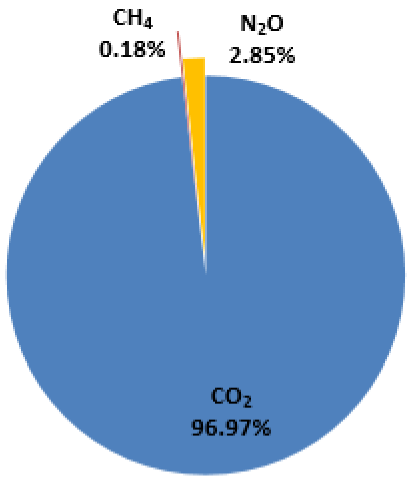


**Figure 3.21 GHG emissions in transport sector by gases in 2014**

One of the critical factors influencing $CO_2$ emission is the amount and type of the consumed fuel. In 2014, total fuel consumption in the transport sector, compared to 2013 level, has increased by 5.3 %. In different subsectors various changes have taken place in 2014. In domestic civil aviation the fuel consumption has not changed, whereas in the railway transport it has decreased by 3.0 %. In the road transport the fuel consumption has increased by around 5.9 %, but in domestic navigation it has decreased approximately 2 times.

In total, road transport consumes about 92%, railway – about 7.3% and domestic civil aviation and domestic navigation – the remaining share of fuel.

Diesel oil is the major fuel type in the transport sector and it constitutes 69.9 %, and is followed by gasoline – 21.2 %, but LPG constitutes 6.5% and biofuels (biodiesel and bioethanol) 2.3 % of the total fuel consumption in the transport sector (see Figure 3.22). The share of biofuels has increased from 2.0 % in 2013 up to 2.3% in 2014. Biofuel includes biodiesel and bioethanol and it mainly is used in road transport but small portion is consumed in railway as well. LPG consumption has increased by 11.7% in 2014 compared to 2013.

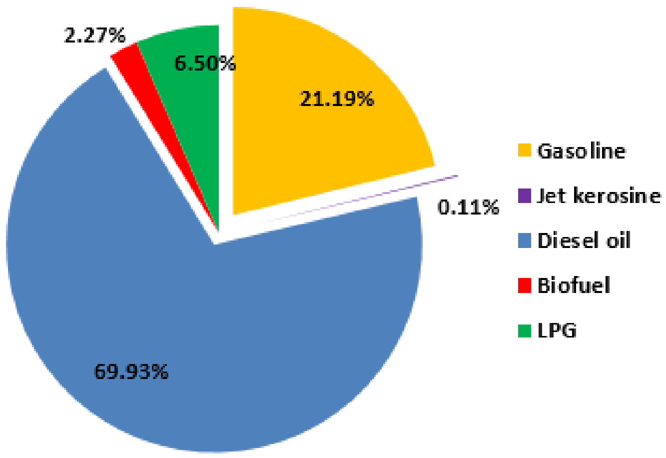


**Figure 3.22 Fuel consumption in transport by fuel type (2014)**

### *3.2.6.1.1 Civil aviation (CRF 1.A.3.a)*

In Latvia, civil aviation, excluding international flights, is really narrow. Therefore the fuel consumption and thus also the volume of GHG emissions is comparably small, constituting mere 0.12% of GHG emissions from transport sector in year 2014 (see Figure 3.20; Figure 3.23). In aviation emissions are calculated for aviation gasoline and jet kerosene. The aviation gasoline is mainly used by small-sized propeller planes but jet kerosene is used by airplanes with turbofan and turbo props engines.

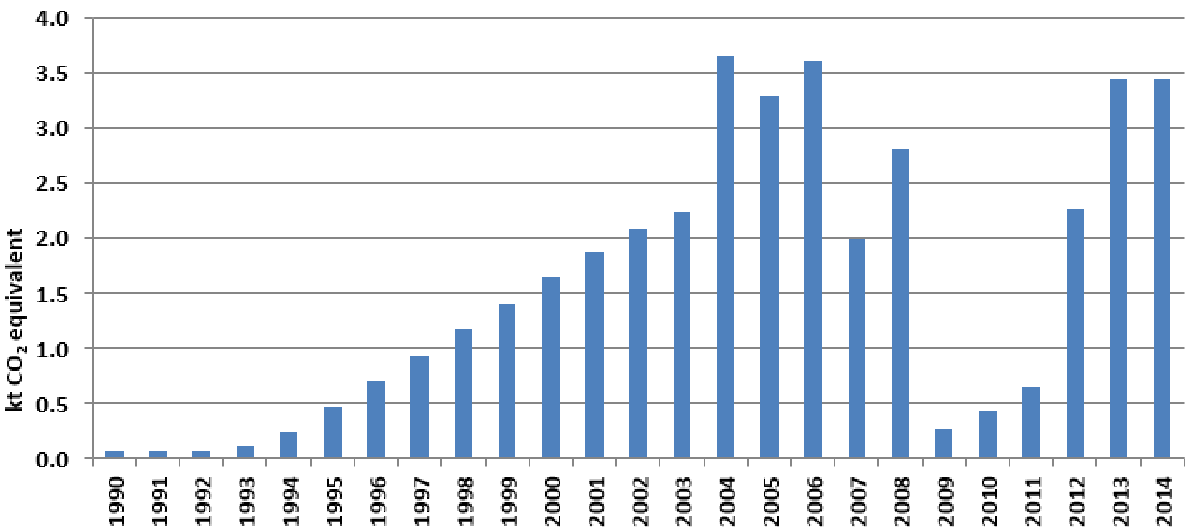


**Figure 3.23 GHG emissions in civil aviation (kt $CO_2$ eq.)**

In Latvia, there are four airports for commercial aviation, of which the largest is the Riga International Airport. Considering that local commercial flights are very dependent on the strategy of local state owned airline company; the number of flights, fuel consumption and emission amount are quite unsteady over the years. As it can be seen, after the state owned (99.8% of shares) local airline company had aborted domestic commercial flights in year

2009, fuel consumption had decreased dramatically in 2009. Today the main activities in civil aviation relates with private flights. Economic recovery starting in Latvia in 2011 has fostered activity and fuel consumption in civil aviation. The results from the carried out additional analyses indicate no evidence of any certain trend in gasoline and jet fuel consumption.

*Methods*

When calculating emissions from civil aviation, two approaches have been applied. 2006 IPCC Guidelines Tier 1 method has been applied when estimating emissions from aviation gasoline for all gases. When calculating emissions from jet kerosene Latvia uses Tier 1 to estimate emissions of $CO_2$ and $SO_2$, and Tier 2 to estimate $CH_4$, $N_2O$ and all other gases. Using Tier 2 approach, emissions for LTO (landing/take off) and cruise are calculated individually. Separate emission factors are provided for LTO and Cruise activities. Prior to the emission calculation, representative aircraft type was chosen, for which the fuel consumption and emission data exist in the EMEP database (EMEP/EEA 2013).

*1. Total Emissions = LTO Emissions + Cruise Emissions*

*2. LTO Emissions = Number of LTOs * Emission Factor of LTOs*

*3. LTO Fuel Consumption = Number of LTOs * Fuel Consumption per LTO*

*4. Cruise Emissions = (Total Fuel Consumption – LTO Fuel Consumption) * EF Cruise*

The summary of the latest key category assessment, methods and EF used is presented in Table 3.28.

**Table 3.28 Summary of source category description, CRF 1.A.3.a**

| CRF | Gas | Method | EF | All sources estimated |
|---|---|---|---|---|
| 1.A.3.a | $CO_2$ | T1 | D | Yes |
| | $CH_4$ | T1,T2 | D | Yes |
| | $N_2O$ | T1, T2 | D | Yes |

*T1 Tier 1; T2 Tier 2; D Default.*

*Activity data*

The data about fuel consumption (see Table 3.29) in aviation is derived from the CSB. CSB has started to separate fuel consumption for domestic flights from total fuel consumption data in aviation as of year 2006. For the time period 1990 – 2005 the data for fuel consumption is used from the study ("Evaluation of fuel consumption for domestic aviation and navigation", FEI, 2004). For 2004 onwards, the air flight statistics is provided by the Riga and Liepaja airports.

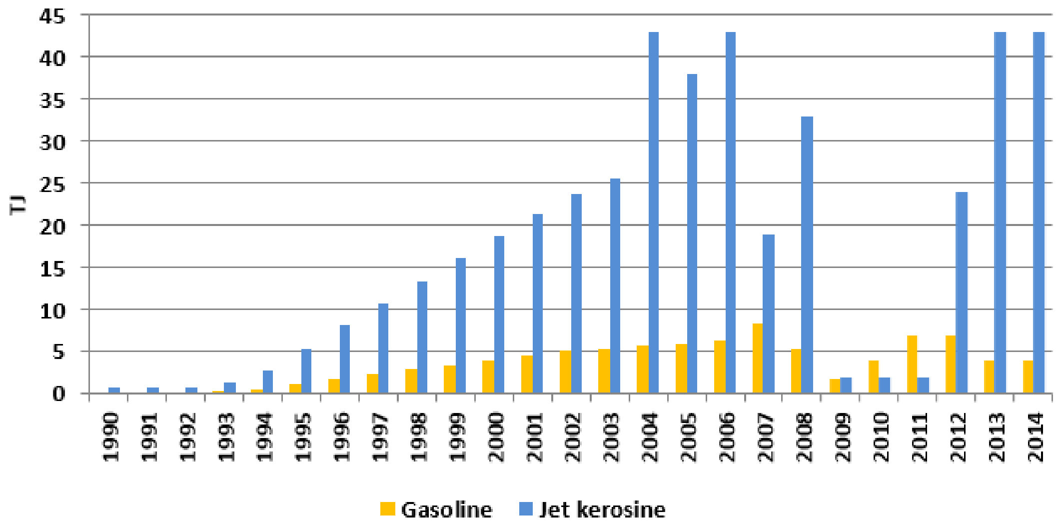


**Figure 3.24 Fuel consumption in domestic civil aviation (TJ)**

The variation in EFs is caused due to the application of 2 methods for emissions calculation for jet kerosene consumption in civil aviation: 1990-2003 with Tier 1 method; 2004-2014 with Tier 2 method. A reason for implementation of 2 methods is availability of necessary activity data (flight numbers) in time periods. To minimize a variation and to improve time series consistency, it is planned to make recalculation of emissions for time period 1990 – 2003 in the next inventory submission.

**Table 3.29 Fuel consumption in domestic civil aviation (TJ)**

| | Jet kerosene | Gasoline |
|---|---|---|
| **1990** | 0.8 | 0.2 |
| **1995** | 5.4 | 1.1 |
| **2000** | 18.8 | 4.0 |
| **2001** | 21.4 | 4.6 |
| **2002** | 23.7 | 5.1 |
| **2003** | 25.5 | 5.4 |
| **2004** | 43.0 | 5.7 |
| **2005** | 38.0 | 6.0 |
| **2006** | 43.0 | 6.4 |
| **2007** | 19.0 | 8.4 |
| **2008** | 33.0 | 5.4 |
| **2009** | 2.0 | 1.7 |
| **2010** | 2.0 | 4.0 |
| **2011** | 2.0 | 7.0 |
| **2012** | 24.0 | 7.0 |
| **2013** | 43.0 | 4.0 |
| **2014** | 43.0 | 4.0 |

*Emission factors*

Default EFs of LTO and cruise (jet kerosene) for civil aviation is used (2006 IPCC Guidelines and EMEP/EEA 2013).

**Table 3.30 Emission factors used in the calculation of emissions from civil aviation (kt/PJ)**

| | $CO_2$ | $CH_4$ | $N_2O$ | NOx | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|
| **Aviation gasoline** | 70.0 | 0.0005 | 0.002 | 0.25 | 0.1 | 0.05 | 0.023 |

### *3.2.6.1.2 Road transport (CRF 1.A.3.b)*

The road transport constituted 91.3 % of GHG emissions in the transport sector in 2014. After the rapid growth in the period 2000 – 2007 (see Figure 3.25), emissions in 2009 have sharply decreased. The main reason was a sharp decreasing of fuel consumption in the road transport in 2009. It decreased by 12.8 %, compared to 2008 level. The major reason for this tendency was recession of the national economy and decrease of transport activities – decrease of passenger km by passenger cars and ton km by freight transport. The road transport is widely used in the local transportation and also for providing cross-border transportation. The freight road transport approximately constitutes 41% (2014) of the total freight in the country (traffic of goods in ton-km). The share has decreased by around 1 % point, compared with year 2013. In the freight road transport the inland freight constitutes approximately 90% of gross – timber products, food products, household goods and building materials are dominant. Fuel consumption in road transport has increased by around 5.9 % in year 2014 compare with 2013. In different fuels various changes have taken place in 2014 compare with 2013. Gasoline consumption has decreased by 2%, whereas biofuel consumption has increased by 14 %, diesel fuel consumption has increased by 7.9% and LPG consumption by 11.7 % (see Figure 3.29 ).

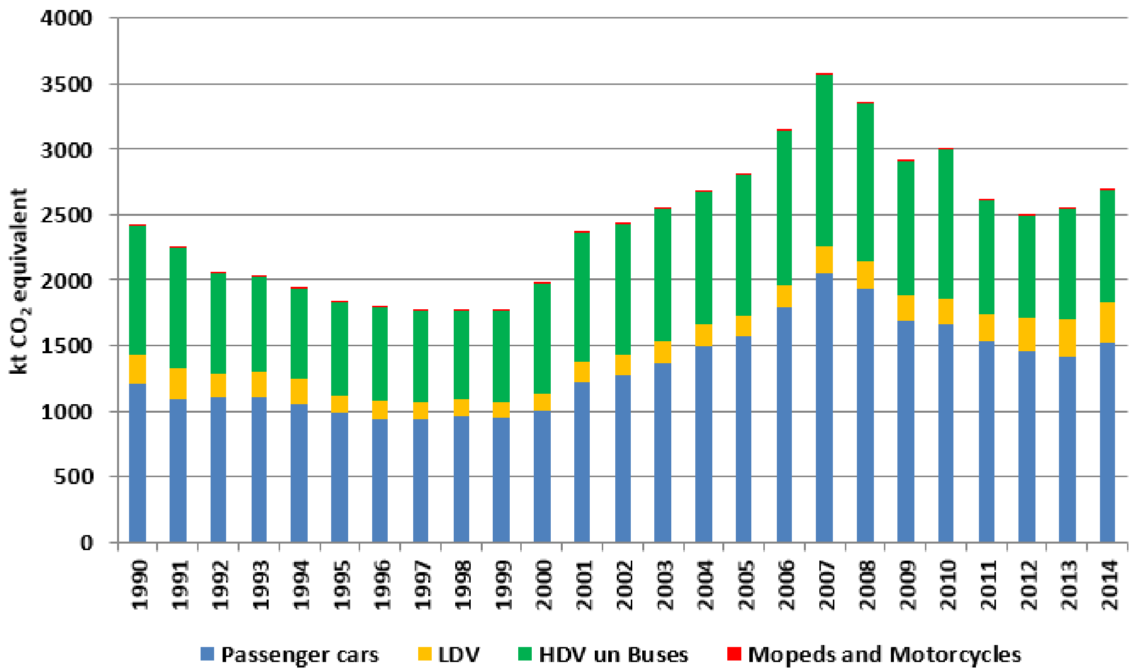


**Figure 3.25 GHG emissions in road transport (kt $CO_2$ eq.)**

Road transport includes five vehicle categories: Passenger cars, Buses, Heavy duty-vehicles (HDV), Light duty-vehicles (LDV) and Mopeds & Motorcycles. In time period 1990 – 2014, essential changes have taken place in the structure of GHG emissions created by the road transport (see Table 3.31). Gasoline has been the most common fuel used for road transports up to year 2000, but in 2014 the amount of diesel used for road traffic is 2.9 times more as gasoline and the emissions of $CO_2$ from diesel surpassed the emissions of $CO_2$ from gasoline as from 2001.

In 2014, emissions from gasoline consumption created by passenger cars were less than that of 1990 level, while emissions created by diesel oil consumption in passenger cars have increased several times. The emissions of Light-duty vehicles (LDV) and heavy-duty vehicles (HDV) gasoline consumption have decreased, but the emissions of diesel oil fuel consumption have essentially increased at this time span.

**Table 3.31 GHG emissions in road transport by vehicle types (kt $CO_2$ eq.)**

| | Passenger Cars | | LDV | | HDV | |
|---|---|---|---|---|---|---|
| | **Gasoline** | **Diesel** | **Gasoline** | **Diesel** | **Gasoline** | **Diesel** |
| **1990** | 1155.05 | 43.06 | 164.22 | 54.69 | 432.27 | 525.09 |
| **1995** | 945.22 | 35.70 | 93.49 | 38.76 | 266.36 | 440.06 |
| **2000** | 863.56 | 119.35 | 48.07 | 77.53 | 144.82 | 659.84 |
| **2001** | 952.95 | 252.82 | 43.60 | 101.49 | 114.65 | 835.30 |
| **2002** | 957.50 | 285.19 | 37.08 | 116.94 | 94.85 | 879.41 |
| **2003** | 973.92 | 359.34 | 32.20 | 121.74 | 83.02 | 907.51 |
| **2004** | 1001.36 | 448.41 | 28.49 | 130.26 | 65.61 | 929.81 |
| **2005** | 992.50 | 520.69 | 24.24 | 129.76 | 54.83 | 1006.67 |
| **2006** | 1110.88 | 621.07 | 23.46 | 147.46 | 49.10 | 1116.17 |
| **2007** | 1225.32 | 767.45 | 22.38 | 179.56 | 43.15 | 1254.12 |
| **2008** | 1118.42 | 767.09 | 19.73 | 180.02 | 34.89 | 1161.83 |
| **2009** | 936.98 | 705.90 | 16.39 | 169.39 | 20.16 | 1002.51 |
| **2010** | 851.79 | 751.82 | 14.62 | 183.59 | 16.72 | 1113.99 |
| **2011** | 788.71 | 670.86 | 15.20 | 190.22 | 15.91 | 852.60 |
| **2012** | 665.92 | 681.98 | 17.02 | 235.77 | 13.22 | 760.11 |
| **2013** | 602.56 | 678.73 | 15.64 | 254.48 | 12.41 | 827.12 |
| **2014** | 590.45 | 774.49 | 15.12 | 283.45 | 11.35 | 843.14 |
| **Share of Energy total, 2014** | 8.5% | 11.1% | 0.2% | 4.1% | 0.2% | 12.1% |
| **2014 versus 2013** | -2.0% | +14.1% | -3.3% | +11.4% | -8.5% | +1.9% |
| **2014 versus 1990** | -48.9% | +1698.6% | -90.8% | +418.3% | -97.4% | +60.6% |

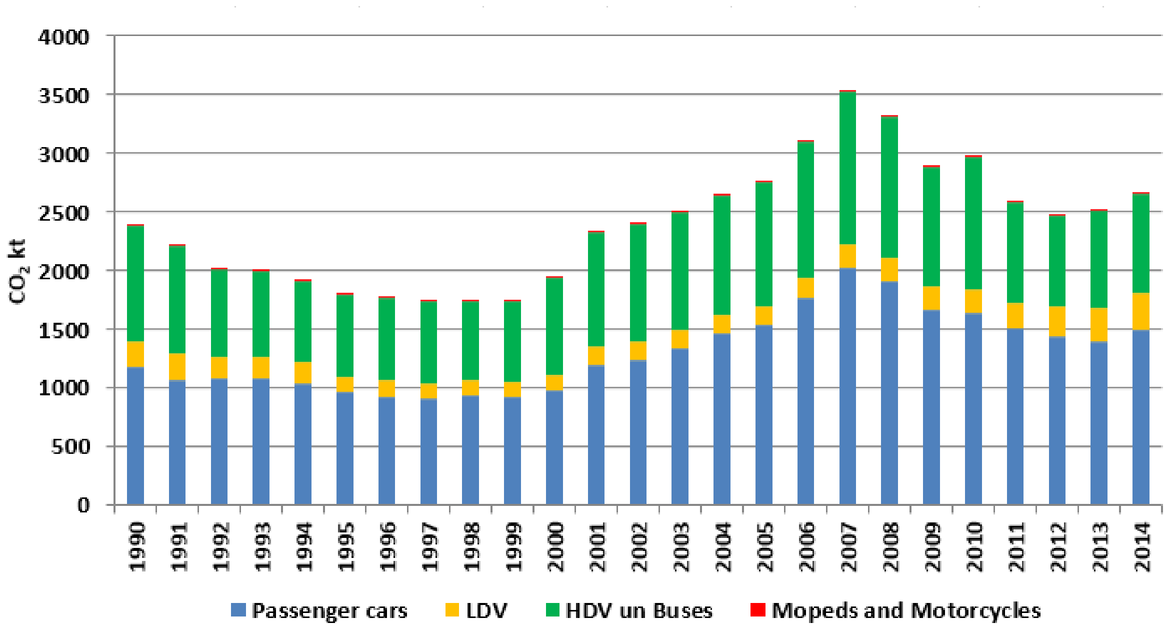


**Figure 3.26 $CO_2$ emissions in road transport by vehicle types**

$CO_2$ emissions are directly fuel-use dependent and, in this way, the development in the emissions reflects a trend in the fuel consumption. As shown in Figure 3.26, the most important emissions source for the road transport is passenger cars and HDV vehicles followed by LDV, buses and motorcycles. Share of $CO_2$ emissions from passenger cars was 57%, HDV and buses 32% and LDV 11% in year 2014. In 2014, $CO_2$ emissions in road transport, compared to 2013 level have increased by 5.7 %.

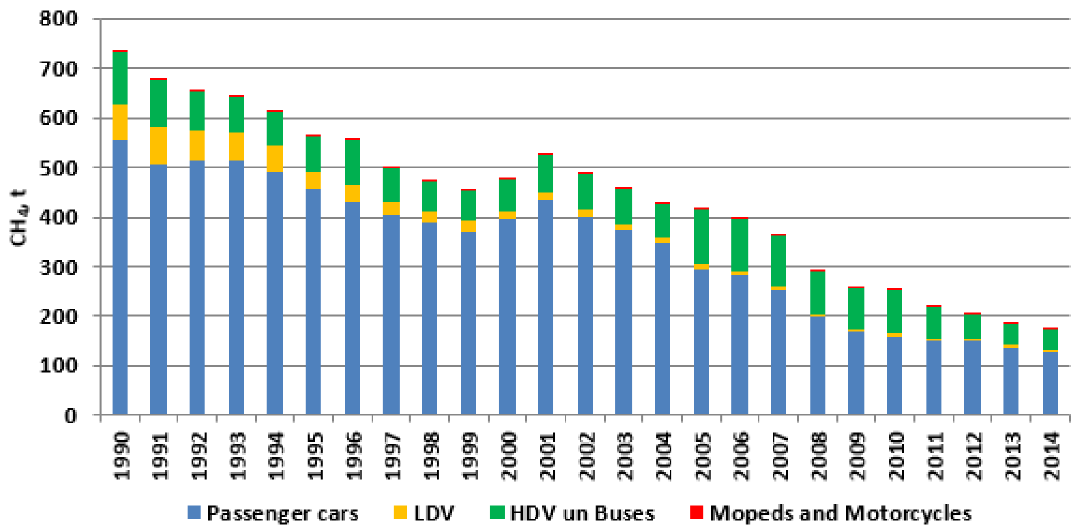


**Figure 3.27 $CH_4$ emissions in road transport by vehicle types**

$CH_4$ emissions present consistent decrease trend within the whole period (see Figure 3.27). In 2014, $CH_4$ emissions in road transport, compared to 2013 level have decreased by 4.8 %. The majority of $CH_4$ emissions from the road transport come from gasoline passenger cars (71.8%). The substantial emission drop from 2001 onwards is explained by the sharp penetration of EURO3, EURO4 and EURO5 passenger cars into the Latvia fleet and additionally in years 2009 - 2014 with decreasing of gasoline consumption by passenger cars.

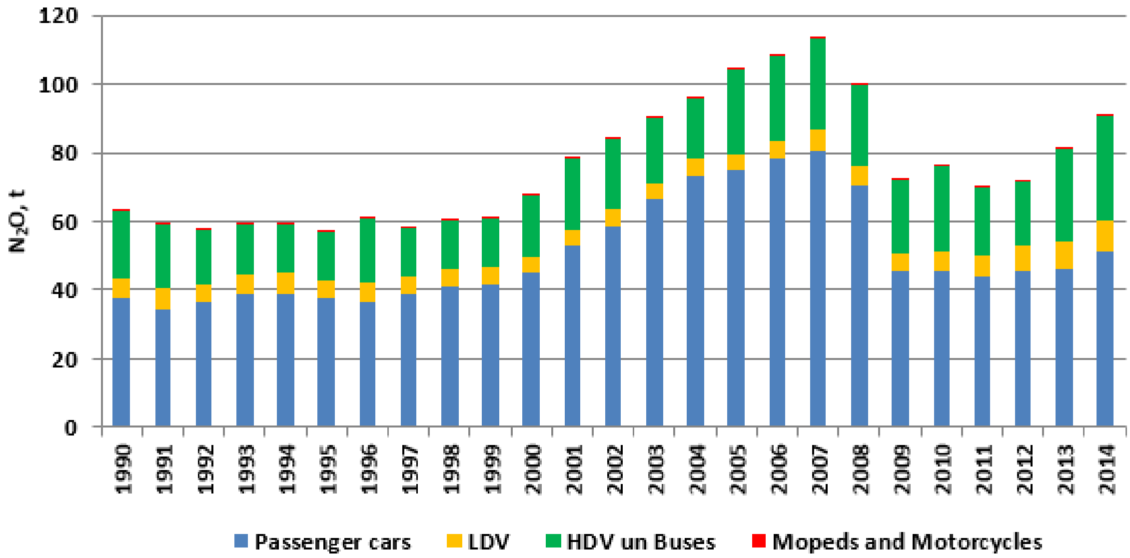


**Figure 3.28 $N_2O$ emissions in road transport by vehicle types**

In 2014, $N_2O$ emissions in road transport, compared to 2013 level have increased by 11.2 %. Taking into account that $N_2O$ emission rates are largely dependent from implemented combustion and emission control technologies, different factor interaction characterises the trend of $N_2O$ changes.

To analyze the trend of $N_2O$ emission at first the significance of different emission sources should be clearly identified. The passenger cars (Figure 3.28) contribute 56.5%, LDV 9.9% and HDV and busses 33.4% of total $N_2O$ emission in Latvia's road transport. Thus the $N_2O$ emission trend is mainly determined by the change in the technologies and fuel used by passenger cars.

Regarding total $N_2O$ emission created by the fleet of Latvia passenger cars, gasoline fuelled passenger cars contribute slightly above 35%, the rest is emitted by diesel fuelled passenger cars. Important, in the period after year 2005 the average $N_2O$ emission factor (t/TJ) for gasoline fuelled passenger cars has tendency to decrease due to change in the relative share of EURO3 and EURO4 cars and EURO5 cars. The $N_2O$ emission factor (g/km) of gasoline fuelled passenger cars of the EURO1 and EURO2 classes is more than twice higher compared to the factor of gasoline fuelled passenger cars of the EURO3 and EURO4 classes. The mileage shares in 2014, calculated by summing the shares of EURO3 and EURO4 and EURO5 gasoline passenger cars, has increased almost twice – from 29.5% to 58.2% of the total gasoline passenger cars mileage, compared to year 2005.

At the same time, one can see the opposite trend in the group of diesel passenger cars. The $N_2O$ emission factor (g/km) of EURO3 and EURO4 and EURO5 diesel passenger cars is per about 60% higher than the emission factor for EURO1 and EURO2 diesel passenger cars. Thus, due to the significant rise of the mileage share of EURO3, EURO4 and EURO5 cars – from 24% (year 2005) up to 69.8% (year 2014) of the total diesel passenger cars mileage, the average $N_2O$ emission factor (t/TJ) for diesel passenger cars has also slightly increased.

*Methods*

For road transport, the detailed methodology is used to make annual estimates of the Latvian emissions, as described in the 2006 IPCC Guidelines and EMEP/EEA 2013. The actual calculation is made with a COPERT IV model[19]. COPERT IV provides factors for fuel consumption and for all exhaust emission components which are included in the national inventory. For several reasons, COPERT IV is regarded as the most appropriate source of road traffic fuel consumption and emission factors. First of all, very few Latvia's emission measurements exist, so data are too scarce to support emission calculations on a national level. Secondly, the COPERT model is regularly updated with new experimental findings from European research programmes and, apart from updated fuel-use and emission factors, the use of COPERT IV by many European countries ensures a large degree of cross-national consistency in reported emission results.

In COPERT IV, fuel consumption and emission simulation can be made for operationally hot engines, taking into account gradually tighten emission standards and emission degradation due to catalyst wear. Furthermore, the emission effects of cold-start and evaporation are simulated. Estimation of evaporative emissions of hydrocarbons and the inclusion of cold start emission effects are dealt with in the Latvian inventory by using LEGMA meteorological input data for ambient temperature variations during months; the distribution of evaporate emissions in the driving modes are used default by COPERT IV model.

Corresponding to the COPERT IV fleet classification, all vehicles in the Latvia's fleet are grouped into vehicle classes, subclasses and layers (see Annex A.3.5). The layer classification is a further division of vehicle sub-classes into groups of vehicles with the same average fuel consumption and emission behaviour, according to EU emission legislation levels.

Trip-speed dependent basis factors for fuel consumption and emissions are implemented. The fuel consumption and emission factors used in the Latvia inventory are taken from the COPERT IV model. The summary of the methods and EF used is presented in Table 3.32.

**Table 3.32 Summary of source category description, CRF 1.A.3.b**

| CRF | Gas | Method | EF | All sources estimated |
|---|---|---|---|---|
| 1.A.3.b | $CO_2$ | T2 | CS | Yes |
| | $CH_4$ | T2 | D (COPERT model) | Yes |
| | $N_2O$ | T2 | D (COPERT model) | Yes |

*T2 Tier 2; CS Country Specific; D Default.*

To calculate $CO_2$ emissions from lubrication oil using in car's engines in road transport it is calculated amount of oil, which the oil film developed on the inner cylinder walls. This oil film further is exposed to combustion and is burned along with the fuel. A calculation of lubricant oil consumption for engine operation has been performed using a typical oil consumption factors for different vehicle types, fuel used and vehicle age (see Table 3-28 EMEP/EEA 2013). Based on this calculated lubricant oil consumption and using default EF (2006 IPCC Guidelines) $CO_2$ emissions for lubricant oil burning for engine operation has been calculated.

[19] www.emisia.com

For estimating $CO_2$ emissions from use of urea-based additives in catalytic converters (non-combustive emissions), it is used equation from 2006 IPCC Guidelines:

$$Emission = Activity \times \frac{12}{60} \times Purity \times \frac{44}{12}$$

*where:*
*Emissions - $CO_2$ Emissions from urea-based additive in catalytic converters (kt $CO_2$)*
*Activity - amount of urea-based additive consumed for use in catalytic converters (kt)*
*Purity - the mass fraction (= percentage divided by 100) of urea in the urea-based additive*
*12/60 - conversion from urea to carbon*
*44/12 - conversion from carbon to $CO_2$*

In calculations, it is assumed that 75% of the HDV (starting with Euro IV class and later) the urea-based additives are used in catalytic converters. The activity level is 3 percent of diesel consumption by the HDV. Thirty-two and half percent is taken as default purity. Estimated $CO_2$ emissions are reported in the IPPU sector (CRF 2).

*Activity data*

As a basis for model input information CSB and LR Road Traffic Safety Directorate (RTSD) data is used. CSB data have been used considering the fuel consumption, RTSD collected and published data have been used considering stock of road transport in Latvia. Total mileage data for passenger cars, light duty trucks, heavy duty trucks and buses produced by the RTSD is used for the years 1996-2014. The summary of the data sources used in emission calculation for road transport are presented in Table 3.33.

**Table 3.33 Activity data and sources used for emission calculation in road transport**

| Activity data | Source of activity data | Remarks |
|---|---|---|
| Fuel consumption | Calculated consumption by COPERT IV model | Calibrated with national statistics. Deviation less than 0,15% |
| Number of cars | Road Traffic Safety Directorate | For calculation it is used number of cars with permission to participate in traffic |
| Number of cars by fuel and vehicle type | Road Traffic Safety Directorate and expert calculation | Based on available data cars are grouped by fuel type, engine power, age and vehicle categories according to emission control system |
| Distance travelled by cars by fuel and vehicle type | Road Traffic Safety Directorate expert calculation | Based on an average data by cars classes it is modelled by fuel type, engine power, age and vehicle categories |
| Emission factors | National specific for $CO_2$ emissions, COPERT emission factors for $CH_4$ and $N_2O$ | $CO_2$ emission factors are based on carbon content in fuel.<br>1990 – 1999 EF for unleaded gasoline is 68.6;<br>2000 - onwards EF gasoline is 71.18<br>1990 – onwards EF diesel oil 74.0 |

General information about activity data is presented in Figure 3.30- Figure 3.36 (number of cars and their split by sub-classes and layers). Before emission calculation COPERT IV model was calibrated to be consistent with actual fuel consumption (energy statistics see Table 3.34). Deviation between fuel consumption in COPERT model and statistics is less than 0.1%. Thus we can say that all emission calculation is based on fuel consumption amount.

**Table 3.34 Fuel consumption in road transport (TJ)**

| | Gasoline | Diesel oil | LPG | Natural gas | Biofuel (biodiesel and bioethanol) |
|---|---|---|---|---|---|
| **1990** | 24200 | 8328 | 592 | 335 | - |
| **1995** | 17996 | 6883 | 501 | 33 | - |
| **2000** | 14520 | 11472 | 865 | 68 | - |
| **2001** | 15268 | 15934 | 865 | 101 | - |
| **2002** | 14960 | 17166 | 865 | 68 | - |
| **2003** | 14950 | 18611 | 956 | 68 | - |
| **2004** | 15038 | 20225 | 1047 | 68 | - |
| **2005** | 14730 | 22180 | 1093 | 68 | 107 |
| **2006** | 16313 | 25235 | 1184 | 68 | 100 |
| **2007** | 17852 | 29488 | 1093 | 67 | 71 |
| **2008** | 16269 | 28256 | 956 | 33 | 82 |
| **2009** | 13586 | 25154 | 865 | 4 | 173 |
| **2010** | 12308 | 27449 | 989 | 1 | 1102 |
| **2011** | 11432 | 22945 | 1184 | - | 844 |
| **2012** | 9697 | 22465 | 1858 | - | 742 |
| **2013** | 8794 | 23539 | 2368 | - | 737 |
| **2014** | 8617 | 25409 | 2646 | - | 840 |

As seen in Figure 3.29 the fuel consumption has essentially changed in the time period 1990 – 2014. The gasoline consumption from the highest consumption in 1990 has decreased till 1999, reaching the lowest consumption and after six year stabilization the increase was seen in 2006 and 2007. Consumption of gasoline had decreased in 2014 by 0.2% compared to 2013. Whereas diesel fuel consumption starting from 1997 has increased gradually till 2007. While it decreased in 2008 and 2009 mainly due to economic recession. Diesel fuel consumption has increased in 2014 by 8.3% compared to 2013. Substantial LPG consumption increasing in road transport was observed starting from 2011.

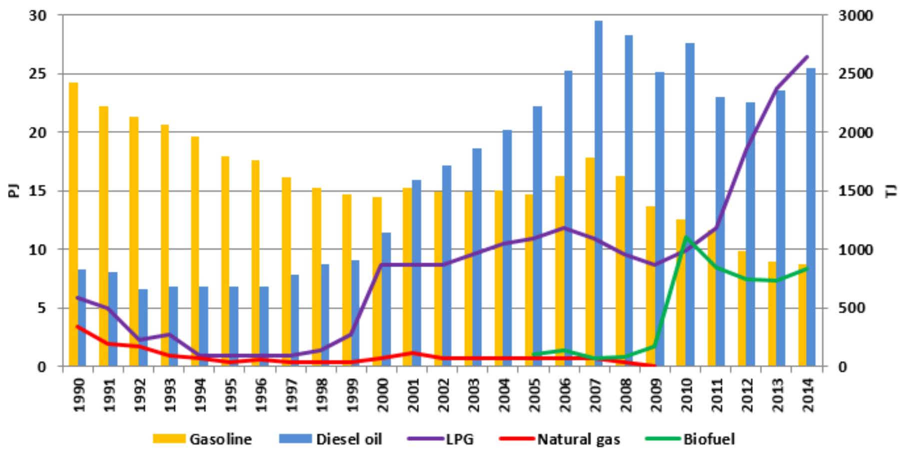


**Figure 3.29 Development of Fuel consumption in road transport (TJ)[20]**

[20] *LPG, natural gas and biofuel on secondary axes*

The vehicle numbers per passenger cars sub-class and layers are shown in Figure 3.30.

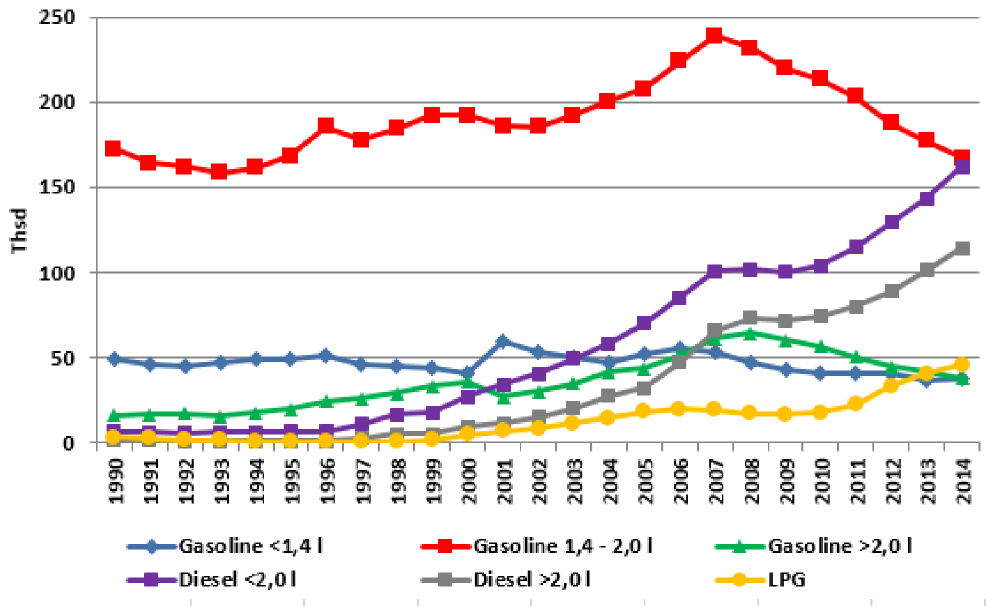


**Figure 3.30 Distribution of passenger cars fleet by sub-classes (Thsd)**

Analyzing the development of the passenger car fleet in the time period 1990 – 2014 (Figure 3.31, Figure 3.32), following features can be noted:

- Cars with a gasoline engine of a capacity > 2.0l constitute the major part;
- Cars with a gasoline engine of a capacity < 1.4l during the whole period have small changes and it`s constitute approximately 7% in year 2014 from total passenger cars;
- Cars with a gasoline engine of a capacity >2.0l starting from year 2010 have a small increasing in their share of total passenger cars;
- As of 2000, the number of cars with diesel engines, both, < 2.0l and > 2.0l, grow rapidly and its share is 48.9% from the total number of passenger cars in 2014;
- As of 2005, in the car fleet with a gasoline engine, the number of EURO 3 and EURO 4 cars grows rapidly. In 2014 a share of EURO3 and EURO4 and EURO5 and EURO6 cars constitutes 26.4%;
- As of 2005, in the car fleet with a diesel engine, the number of EURO 4 and EURO 5 cars grows rapidly. In 2014 a share of EURO4, EURO5 and EURO6 cars constitute 27.4%.

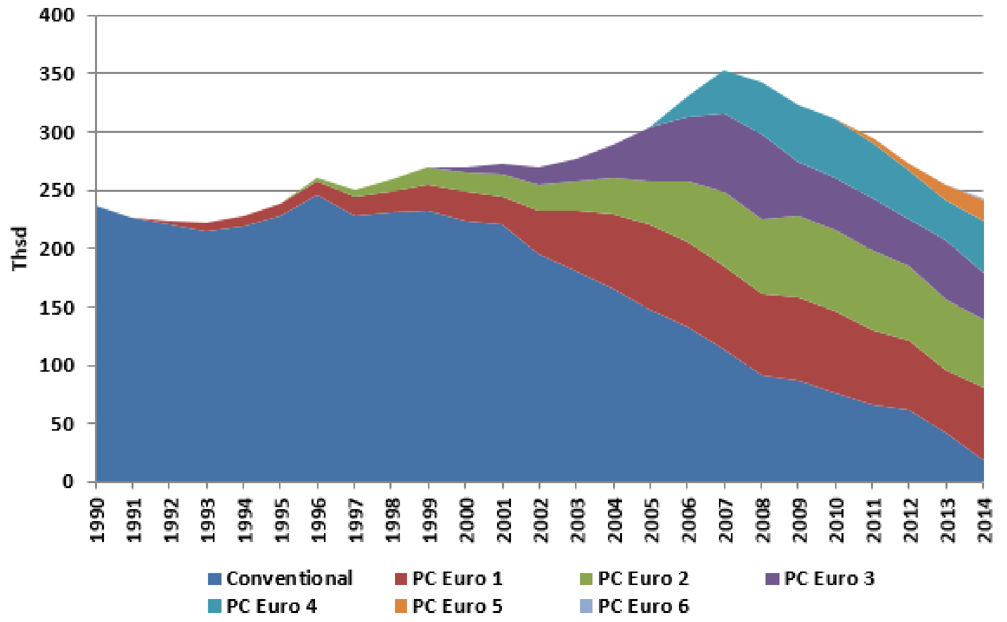


**Figure 3.31 Distribution of gasoline passenger cars fleet by layers (Thsd)**

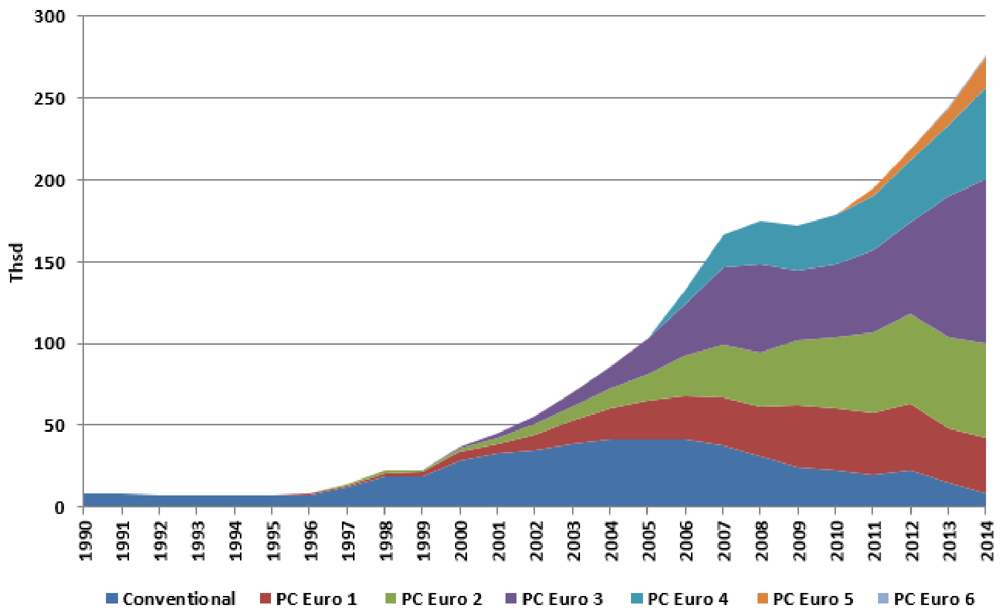


**Figure 3.32 Distribution of diesel oil passenger cars fleet by layers (Thsd)**

Analyzing the development of LDV fleet (Figure 3.33, Figure 3.34) in the time period 1990-2014, major features can be noted as follows:

- As of 1996, the number of cars with a gasoline engines have decreased;
- As of 2000, the number of cars with a diesel engine rapidly increases. In 2014 the share of diesel cars is 92.7%;
- As of 2005, the number of EURO4 and EURO5 cars have increased. In 2014 the share of EURO4, EURO5 and EURO6 cars constitute 45.5%;

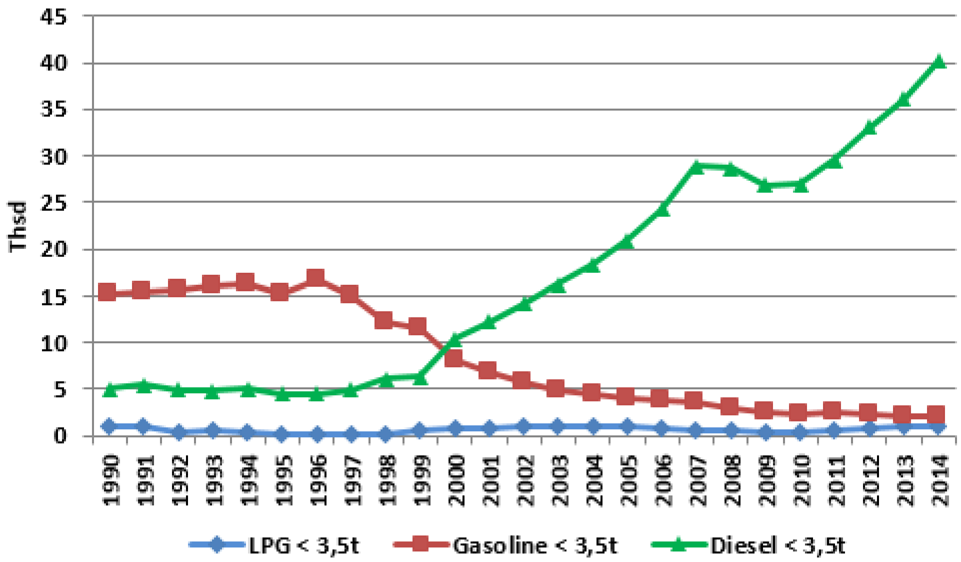


**Figure 3.33 Distribution of light duty vehicles fleet by sub-classes (Thsd)**

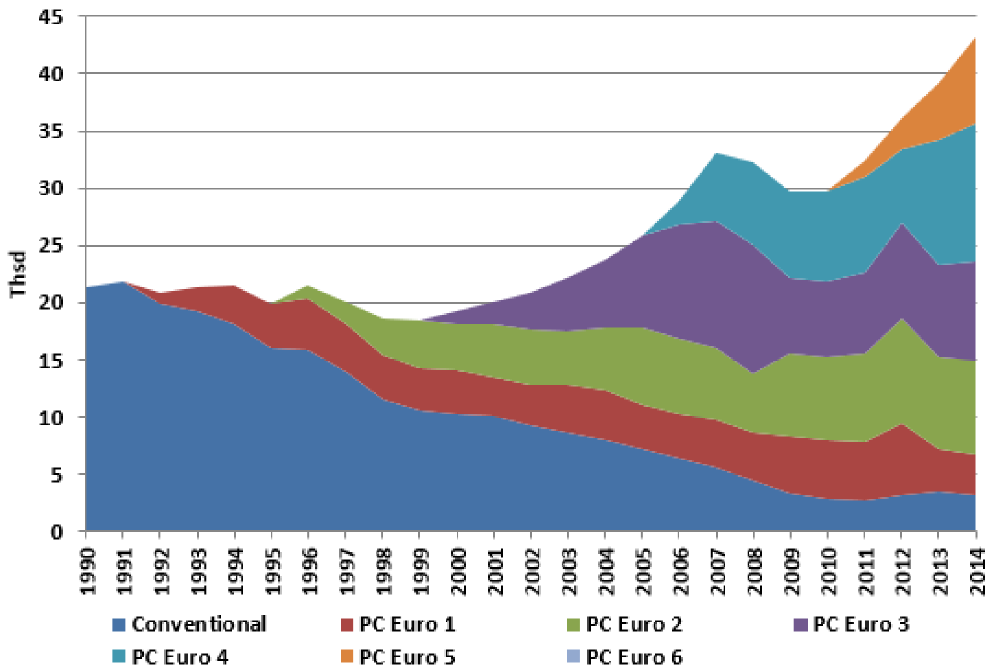


**Figure 3.34 Distribution of light duty vehicles fleet by layers (Thsd)**

The vehicle numbers per HDV sub-classes and layers are presented in Figure 3.35 and Figure 3.36. Analyzing the development of HDV fleet in the following time period, major features can be noted as follows:

- Since 2000, the number of cars with a gasoline engines have rapidly decreased. The share of gasoline cars has decreased from 33% to 4.1 % corresponding years 2000 and 2014;
- Since 2000, the number HDV cars with tonnage 14-34 t and a diesel engine starts to increase;

- As of 2000, average age reduction of cars takes place gradually. In 2014 the share of EURO IV, EURO V and EURO VI cars constituted 41.2%.

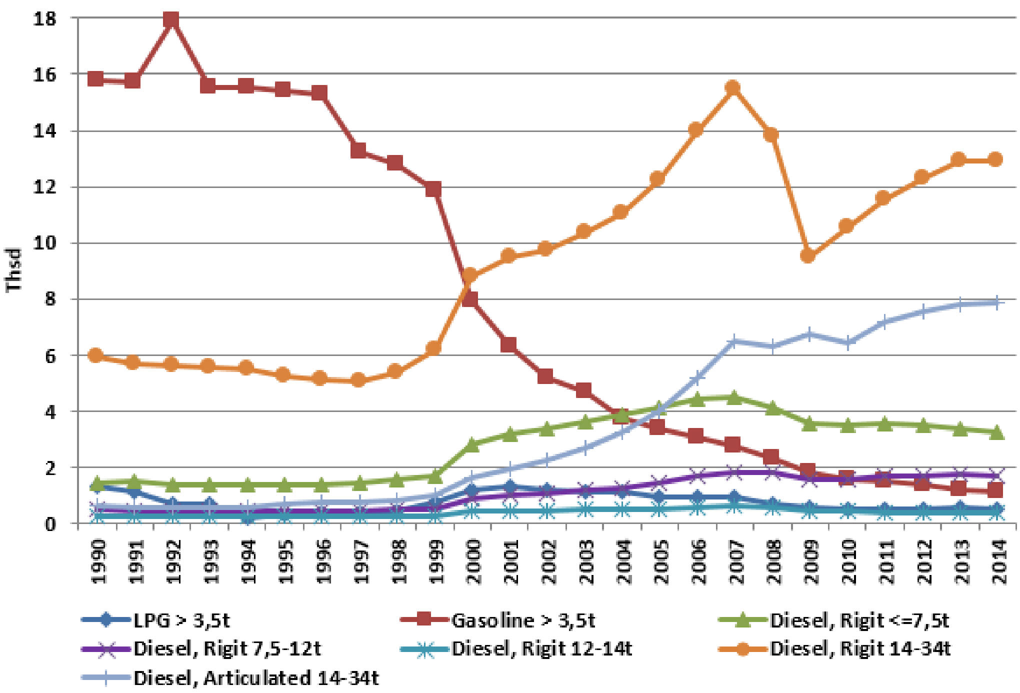


**Figure 3.35 Distribution of heavy duty vehicles fleet by sub-classes (Thsd)**

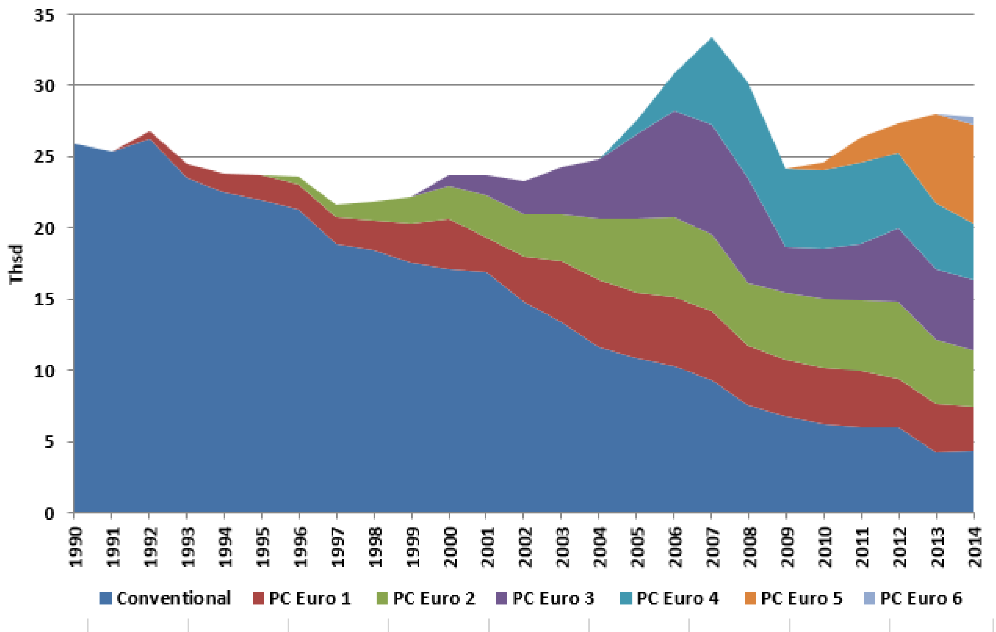


**Figure 3.36 Distribution of heavy duty vehicles fleet by layers (Thsd)**

*Emission factors*

$CO_2$ emissions in COPERT IV model were calculated using country-specific $CO_2$ emission factor that are calculated based on the information available on the C and H content in fuel.

Country specific EF for $CO_2$ emission calculation (gasoline, diesel oil) in road transport is used:

- 1990 – 2014 EF diesel oil 74.0 kg/GJ ("Guidance Manual for $CO_2$ emission estimations" (2004) see Annex A.3.2 of NIR);
- 1990 – 2014 EF for unleaded gasoline is 71.18 kg/GJ.

Country specific $CO_2$ EF for gasoline has been calculated within a research "Research on carbon content in transport fuels" in 2012. The research on C content in fuels carried out in 2012 quantified C and H content in gasoline. For gasoline the C content is 86.3%, further it is calculated NCV for gasoline (43.97 MJ/kg) and estimated $CO_2$ emission factor in accordance with 2006 IPCC Guidelines. Based on the results of this research, $CO_2$ EF of gasoline has been calculated - 71.18 kg/GJ. Although quantification of C and H content in gasoline has been performed for fuel with a requirement for gasoline quality which is in force since January 1, 2009, the updated $CO_2$ EF is implemented for emissions calculation 1990-2008 as well to ensure consistent time series. Rest of emission factors comes from the COPERT IV model.

#### *3.2.6.1.3 Railways (CRF 1.A.3.c)*

In 2014, the fuel consumption in railway constituted 8.05% of GHG emissions from the total GHG emissions in transport. Freight transport has a dominant role in railway. The railway transport accomplishes around 59% (2014) of the total freight transport in Latvia (traffic of goods in ton-km) and the transit transport traffic is dominant. In 2009 and 2010, transported freight along the railway and therefore the diesel consumption has a slightly decreased, compared to 2008 level. Due to dependence on transit transport of goods from Russia fuel consumption has decreased by approximately 3.0% in 2014 compared to 2013. It results in decreased GHG emissions by 4.2% in 2014 compared to 2013 level. Emission calculation in railway transport includes railway transport operated by diesel locomotives.

Railway related fuel consumption is key sources for $CO_2$ emissions. In 2014, total GHG emissions in railway, compared to 1990 level have decreased by 59.8% (see Figure 3.37).

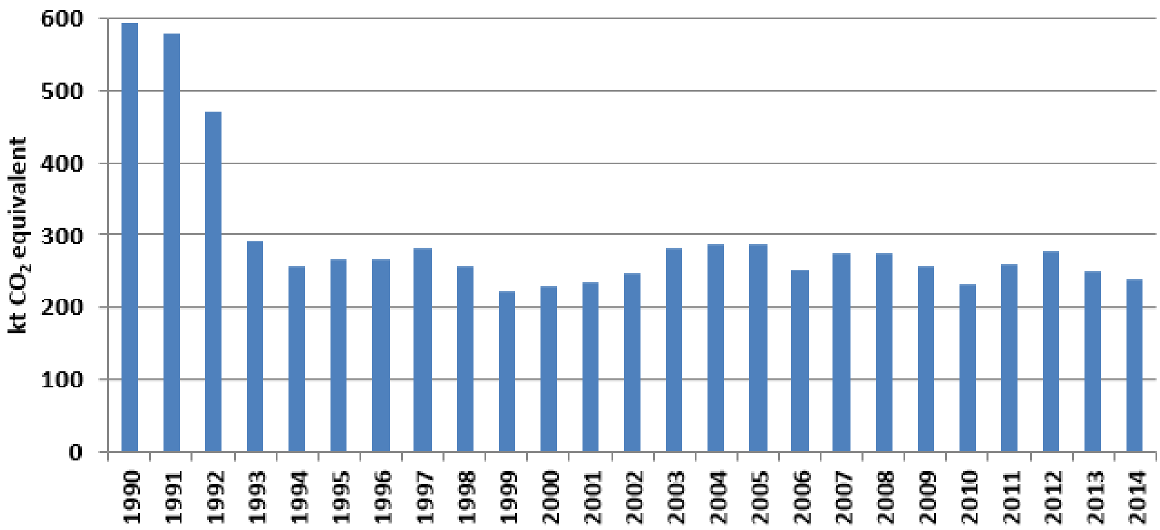


**Figure 3.37 Development of GHG emissions in railway (kt $CO_2$ eq.)**

## Methodological issues

### *Methods*

When calculating emissions from railway, 2006 IPCC Guidelines Tier 1 and Tier 2 methods have been applied. The summary of the latest key category assessment, methods and EF used is presented in Table 3.35.

**Table 3.35 Summary of source category description, CRF 1.A.3.c**

| CRF | Gas | Method | EF | All sources estimated |
|---|---|---|---|---|
| 1.A.3.c | $CO_2$ | T2 | CS | Yes |
| | $CH_4$ | T1 | D | Yes |
| | $N_2O$ | T1 | D | Yes |

*T1 Tier 1; T2 Tier 2; CS Country Specific; D Default.*

### *Activity data*

The data about diesel oil consumption in railway are derived from the CSB. Development of diesel oil consumption is presented in Figure 3.38 and Table 3.36. As we see, starting from 2010 a small portion of biodiesel is used in railway.

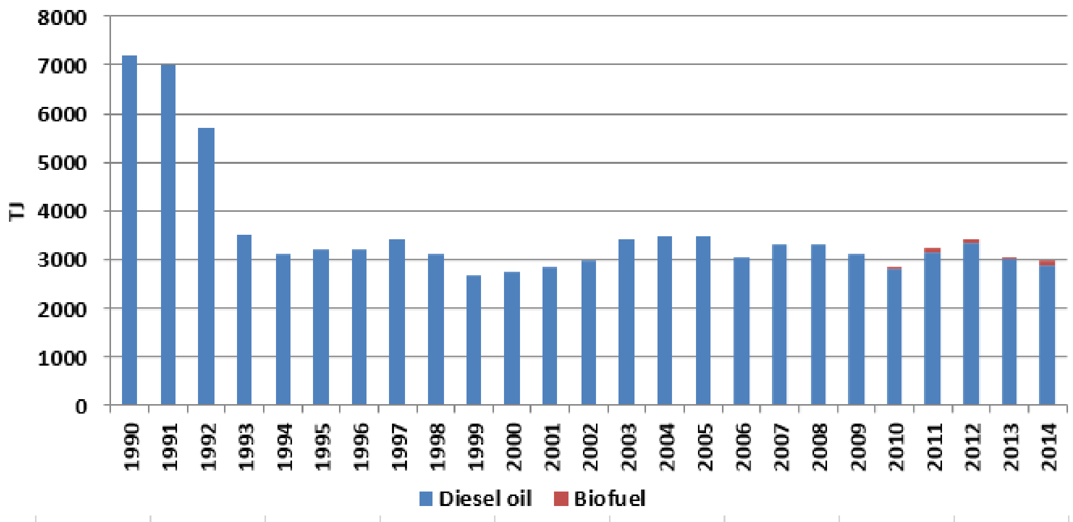


**Figure 3.38 Development of fuel consumption in railway (TJ)**

**Table 3.36 Fuel consumption in railway (TJ)**

| | Diesel oil | Biodiesel |
|---|---|---|
| **1990** | 7181 | - |
| **1995** | 3229 | - |
| **2000** | 2762 | - |
| **2001** | 2847 | - |
| **2002** | 2974 | - |
| **2003** | 3399 | - |
| **2004** | 3484 | - |
| **2005** | 3484 | - |
| **2006** | 3059 | - |
| **2007** | 3314 | - |
| **2008** | 3314 | - |
| **2009** | 3102 | - |

| | Diesel oil | Biodiesel |
|---|---|---|
| **2010** | 2804 | 35 |
| **2011** | 3144 | 91 |
| **2012** | 3357 | 63 |
| **2013** | 3017 | 48 |
| **2014** | 2889 | 83 |

*Emission factors*

Country specific EF for $CO_2$ emissions is used ("Guidance Manual for $CO_2$ emission estimations" (2004) see Annex A.3.2 of NIR). Rest of emission factors comes from 2006 IPCC Guidelines and EMEP/EEA 2013 (see Table 3.37).

**Table 3.37 Emission factors used in the calculation of emissions from railway**

| | $CO_2$ | $CH_4$ | $N_2O$ | NOx | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|
| | kt/PJ | kt/PJ | kt/PJ | kt/PJ | kt/PJ | kt/PJ | kt/PJ |
| **Diesel oil** | 74 | 0.00415 | 0.0286 | 1.2332 | 0.251823 | 0.10943 | 0,02353 (2003-2004) 0,09414 (1990-2007) 0.04707 (2008-2014) |

### *3.2.6.1.4 Domestic Navigation (CRF 1.A.3.d)*

In 2014, fuel consumption in navigation was responsible for around 0.5% of GHG emissions from total GHG emissions in transport.

Although Latvia has several ports, domestic navigation that providing transport of freight or passengers among local ports is not developed. Major activities in ports deal with international freight transport. In domestic navigation, the emissions are calculated for miscellaneous vessels (tugs, barges, towboats, and icebreakers), recreational crafts and personal boats (see Figure 3.39).

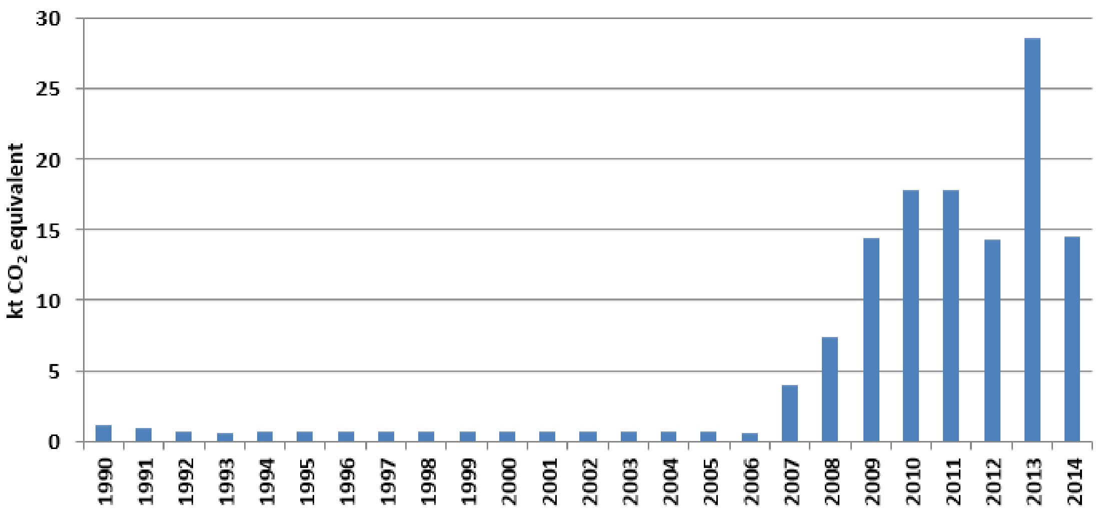


**Figure 3.39 GHG emission development in domestic navigation (kt $CO_2$ eq.)**

Fuel consumption and $CO_2$ emissions trend in domestic navigation mainly depends from international (import, export) cargo activities in ports (cargo turnover and number of vessels served in ports). During the period 2006-2014 international cargo turnover in ports has increased by approximately 24.5% and number of served vessels by approximately 10%. This increasing trend of activity partly explains fuel consumption increasing. On the other hand, fuel consumption is affected by the number of vessels serviced in ports. As shown in Figure 3.40 in spite of the rapid increase in the volume of cargo at the port of Riga, the number of serviced ships has remained almost unchanged. The main reason for this trend is the increase in the gross tonnage of vessels. The most significant increase was registered in the average tanker gross tonnage, but also in other cargo carrier groups (container, dry bulk carriers).

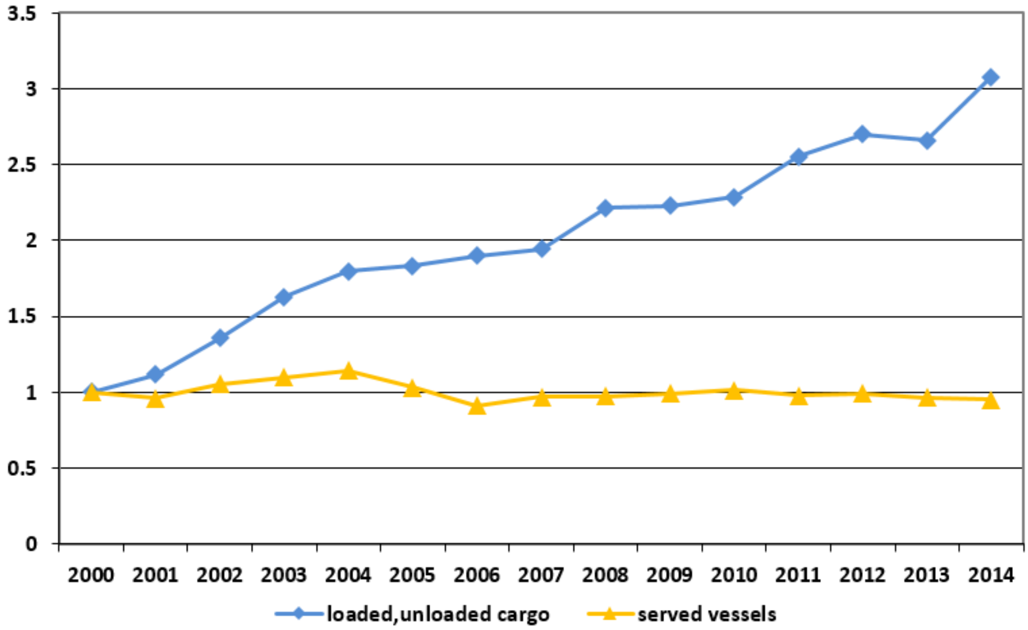


**Figure 3.40 Loaded, unloaded cargo and served vessels at Riga port (2000 = 1)**

Other additional factor which makes impact to fuel consumption in domestic navigation is weather conditions. This we can definitely see for 2010 and 2011 when air temperature was low and sea was covered by ice. An ice breaker operated many months to ensure operation of ports in 2010 and 2011. This has made an impact on fuel consumption in 2010 and 2011.

Before GHG emission calculation is performed CSB is asked to check and further confirm fuel consumption in sector if fluctuation is more than 20% points compare to the previous year.

<u>Methodological issues</u>

*Methods*

When calculating emissions from navigation, Tier 1 and Tier 2 methods from 2006 IPCC Guidelines have been applied. Country specific $CO_2$ EF is used for emission calculation from diesel fuel consumption. The summary of the latest key category assessment, methods and EF used is presented in Table 3.38.

**Table 3.38 Summary of source category description, CRF 1.A.3.d**

| CRF | Gas | Method | EF | All sources estimated |
|---|---|---|---|---|
| 1.A.3.d | $CO_2$ | T1,T2 | CS; D | Yes |
| | $CH_4$ | T1 | D | Yes |
| | $N_2O$ | T1 | D | Yes |

*T1 Tier 1; T2 Tier 2; CS Country Specific; D Default.*

### *Activity data*

The data about diesel oil consumption and gasoline consumption in domestic navigation are derived from the CSB. CSB have started to collect data about diesel oil consumption and gasoline consumption in domestic navigation from 2006. For the time period 1990 – 2005 the data for fuel consumption is used from the study "Evaluation of fuel consumption for domestic aviation and navigation" (FEI, 2004). Development of fuel consumption in domestic navigation is presented in Figure 3.41 and Table 3.39. Diesel oil consumption has decreased approximately 2 times in 2014 compared to 2013.

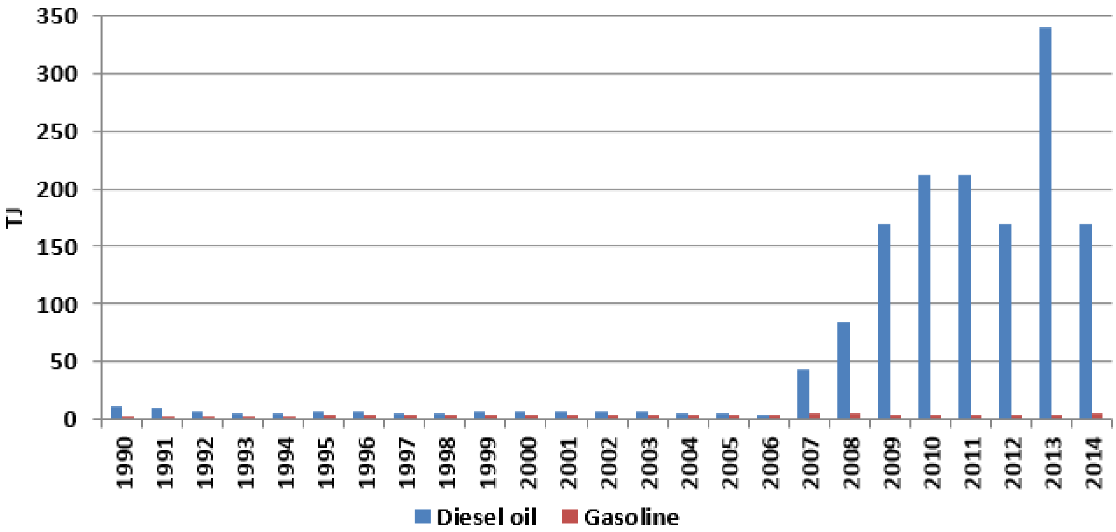


**Figure 3.41 Development of gasoline and diesel oil fuel consumption in domestic navigation**

Variation in local navigation's fuel consumption in 2012-2014 indicates that this consumption is highly dependent on the harbour services' activities. In 2013 there was done harbour deepening of large scale resulting also in significant increase in fuel consumption. After the realization of noted project, the fuel consumption in 2014 come back to roughly 2012 level.

**Table 3.39 Fuel consumption in domestic navigation (TJ)**

| | Diesel oil | Gasoline |
|---|---|---|
| **1990** | 11 | 2 |
| **1995** | 6 | 3 |
| **2000** | 6 | 3 |
| **2001** | 6 | 3 |
| **2002** | 6 | 4 |
| **2003** | 6 | 4 |
| **2004** | 6 | 4 |

| | Diesel oil | Gasoline |
|---|---|---|
| **2005** | 5 | 4 |
| **2006** | 4 | 4 |
| **2007** | 43 | 5 |
| **2008** | 85 | 5 |
| **2009** | 170 | 4 |
| **2010** | 212 | 3 |
| **2011** | 212 | 3 |
| **2012** | 170 | 3 |
| **2013** | 340 | 4 |
| **2014** | 170 | 5 |

*Emission factors*

Default EFs for navigation is used (2006 IPCC Guidelines and EMEP/EEA 2013,Table 3.40).

**Table 3.40 Emission factors used in the calculation of emissions from navigation**

| | $CO_2$, t/TJ | $CH_4$, t/TJ | $N_2O$, t/TJ |
|---|---|---|---|
| **Gasoline** | 69.3 | 0.0473 | 0.000296 |
| **Diesel oil** | 74.0 | 0.004 | 0.003 |

#### 3.2.6.2 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6. Activity data about fuel consumption in transport sector is mainly available from 1990 and they are provided by CSB. Considering that CSB gives approximately 2% statistical sample error for statistical data uncertainty in activity data of fuel consumption in transport is ±2% in 2014. Before GHG emission calculation is performed CSB is asked to check and further confirm fuel consumption in sector if fluctuation is more than 20% points compare to the previous year. Uncertainty range for calculated or modelled activity data (lubricant oil using in cars' engines, gasoline consumption in domestic navigation) is 10 – 20%.

$CO_2$ emission factor was estimated according physical characterization of used fuels in country based on average NCV reported by fuel consumers and carbon content so uncertainty was assigned as quite low about 2% (diesel oil and gasoline in road transport). For rest of fuels in transport sector default $CO_2$ emission factors from 2006 IPCC Guidelines were used and uncertainty was assigned 5%. Default $CH_4$ and $N_2O$ emission factors used in estimation of emissions was taken from 2006 IPCC Guidelines, so uncertainty was assigned 50 %.

In order to maintain consistency with the time-series the estimation procedures have been developed as described above (chapter 1.6.). However, due to the fact that some of the estimations are not based on activity data but on other factors as LTO cycles in civil aviation sector, a certain degree of uncertainty exists. In road transport one important basic parameter for the COPERT IV model is vehicle-km, which is calculated through another model. This second model is based on the mileage driven by the vehicle noted at time of TA (annual inspection/testing of the vehicle) at Road Traffic Safety Directorate. If it is in place sharp changing of some external factors impacted fuel consumption, for example economy recession, fuel price or energy tax, it will not be shown as clearly in the development of vehicle mileage as in statistics on fuel consumption.

To ensure time series consistency any recalculation related with model version updating is realized for all time period. Linear interpolation has been implemented only for cases when activity data fluctuation does not take place.

### 3.2.6.3 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the transport sector in order to achieve these quality objectives. Meetings dedicated for quality ensure and improvement are held annually among inventory and external experts.

All Tier 1 general inventory level QC procedures listed in chapter 1.2. applicable to this sector are used. These measures are implemented every year during the transport sector inventory. In addition, the consumption of every type of fuel in the last year is checked and compared with previous years. If large variations are discovered for certain fuels, responsible CSB staff is contacted for an explanation.

Estimated emissions verification:

- All estimations of the emissions done for a transport sector are checked on the logical mistakes by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogic changes in the activity data and emissions.
- Emissions are checked using time series consistency check for the EF estimated in CRF Reporter. EFs are calculated per fuel, substance and CRF-code and checked against the emission factors to make sure that no calculation errors have occurred when emissions were computed. The calculated air transport emissions have been compared and verified with Eurocontrol's emission data for 2008-2014. The calculated activity data for fuel consumption of LTO and cruise mode and emissions were comparable and very close to those estimated by Eurocontrol.
- For road transport a checking is done on less aggregated level than in CRF. Non $CO_2$ EF changes that are higher than 10% in time series are double-checked and reasonable explanation for EF changes has to be found.

All findings are documented by using check-lists, available on Regulations of the Cabinet of Ministers No. 217 adopted on 27 March 2012 "The National Inventory System of Greenhouse Gas Emission Units". Each expert has to check and fill in QC form for each category taking into account criteria given in QA/QC plan approved in above mentioned national legislation. Potential errors and inconsistencies are documented in the special form and corrections are made if necessary. The QC measures have been implemented concerning used activity data, implemented Guidelines, methods and EF. Form then is sent to National Inventory Compiler and it is archived in FTP folder.

Additional QA/QC checks for Tier2 methodology

For emission calculation in road transport additional QA/QC check approach has implemented. QC activities are realized with emission data and activity data QC.

It is assessed that implemented default EF from COPERT IV model are applicable to national circumstances because model comprises all necessary technologies. Country specific EFs for $CO_2$ are calculated based on 2006 IPCC Guidelines methodology. Activity data (fuel consumption, total number of vehicles) provider CSB has the internal QA/QC procedures based on mathematical model and analysis to avoid logic mistakes. To ensure QA procedure expert from Road traffic and safety Directorate is asked to make peer review about the main assumption implemented in emission calculation.

#### 3.2.6.4 Category-specific recalculations

The following recalculations and improvements of the emission inventories have been made in the transport sector since the emission reporting in 2014 (Table 3.41).

**Table 3.41 Recalculations for Sub-category CRF 1.A.3 Transport**

| Sub-category | Recalculation | Improvements |
|---|---|---|
| Road transport (CRF 1.A.3.b) | $CO_2$ ; $CH_4$; $N_2O$ emissions for 2009 – 2011 have been recalculated | Recalculations have been done due to corrected fuel consumption taking into account CSB corrections. Recalculation affected direct and non direct emissions. $CO_2$ emissions increased by around 1% for years 2010 and 2011 |
| Civil aviation (CRF 1.A.3.a) | $CO_2$ ; $CH_4$; $N_2O$ emissions for 2006 and 2007 have been recalculated | Recalculations have been done due to corrected jet fuel consumption. Recalculation affected direct and non direct emissions. |
| Road transport (CRF A.3.b) | $CO_2$ ; $CH_4$; $N_2O$ emissions for 2012 and 2013 have been recalculated | Recalculations have been done due to improvement of activity data and corrected gasoline consumption. Improvements comprise more precise split of passenger cars, LDV and HDV by subgroups (depending on engine volume) and layers (EURO classes) and mileage. Recalculation affected direct and non direct emissions. $CO_2$ emissions increased by around 1% |

#### 3.2.6.5 Category-specific planned improvements

No improvements are planned for the sector.

### 3.2.7 Other Sectors (CRF 1.A.4)

#### 3.2.7.1 Category description

CRF 1.A.4 Other sectors include emissions from the small combustion of fuels in Commercial/Institutional, Residential sectors and Agriculture/Forestry/Fisheries. In addition, emissions from mobile machinery used in Commercial, Residential and Agriculture and Forestry sectors are included here as off-road. Also emissions from autoproducers are included in relevant sectors of CRF 1.A.4 – according to 2006 IPCC Guidelines these emissions have to be reported in sectors producing them.

In Submission 2016, the CRF subsector 1.A.4. Other sectors were split into subsectors which are in line with 2006 IPCC Guidelines/CRF Reporter structure:

- 1.A.4.a Commercial/Institutional:
  - 1.A.4.a.i Stationary combustion;
  - 1.A.4.a.ii Off-road vehicles and other machinery;
- 1.A.4.b Residential:
  - 1.A.4.b.i Stationary combustion;
  - 1.A.4.b.ii Off-road vehicles and other machinery;
- 1.A.4.c Agriculture/Forestry/Fishing:
  - 1.A.4.c.i Stationary combustion;
  - 1.A.4.c.ii Off-road vehicles and other machinery;
  - 1.A.4.c.iii Fishing.

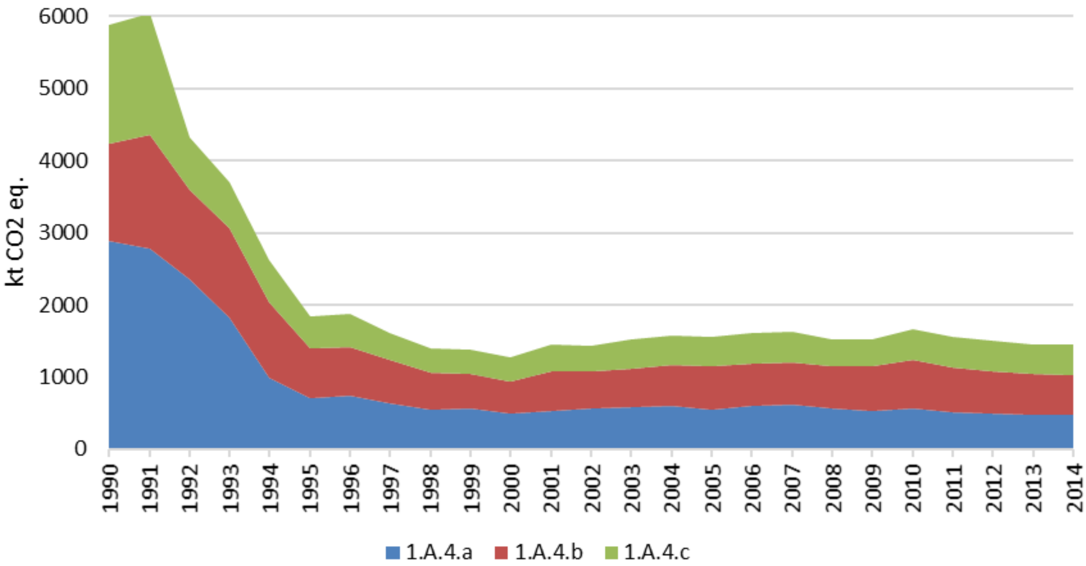


**Figure 3.42 GHG emissions in CRF 1.A.4. Other sectors by subsectors (kt $CO_2$ eq.)**

In Figure 3.42, there can be seen the distribution of GHG emissions in CRF 1.A.4 sector. The largest part of emissions contributes to CRF 1.A.4.b Residential (38.4% in 2014). Other subsectors' shares are quite similar – in 1.A.4.a Commercial/Institutional there are 32.96% from 1.A.4 emissions produced, while in 1.A.4.c Agriculture/Forestry/Fisheries, where also offroad emissions from Fisheries have been included, the share of 1.A.4 emissions is 28.7%

**Table 3.42 Emissions from Other Sectors (CRF 1.A.4) in 1990–2014 (kt)**

| | $CO_2$ | $CH_4$ | $N_2O$ | Aggregate GHGs ($CO_2$, $CH_4$, $N_2O$) | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|---|
| | kt | | | kt $CO_2$ eq. | kt | | | |
| **1990** | 5595.15 | 8.83 | 0.248 | 5889.98 | 22.58 | 162.89 | 17.02 | 34.65 |
| **1991** | 5707.27 | 9.85 | 0.319 | 6048.67 | 25.66 | 158.78 | 16.51 | 32.73 |
| **1992** | 4036.48 | 8.66 | 0.241 | 4324.62 | 19.55 | 140.82 | 15.22 | 26.62 |
| **1993** | 3403.89 | 9.19 | 0.214 | 3697.43 | 17.65 | 148.04 | 15.80 | 22.14 |
| **1994** | 2347.99 | 9.05 | 0.178 | 2627.11 | 13.73 | 145.39 | 15.65 | 17.44 |

| | $CO_2$ | $CH_4$ | $N_2O$ | Aggregate GHGs ($CO_2$, $CH_4$, $N_2O$) | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|---|
| | kt | | | kt $CO_2$ eq. | kt | | | |
| **1995** | 1564.12 | 9.27 | 0.166 | 1845.53 | 11.07 | 140.85 | 16.36 | 9.95 |
| **1996** | 1585.29 | 9.45 | 0.174 | 1873.52 | 11.25 | 148.52 | 17.05 | 10.73 |
| **1997** | 1343.94 | 8.95 | 0.171 | 1618.67 | 9.27 | 139.51 | 16.14 | 8.29 |
| **1998** | 1153.96 | 8.09 | 0.156 | 1402.59 | 7.84 | 133.00 | 15.25 | 6.31 |
| **1999** | 1136.28 | 8.01 | 0.150 | 1381.05 | 8.75 | 128.64 | 15.05 | 5.11 |
| **2000** | 1050.76 | 7.41 | 0.144 | 1278.84 | 8.31 | 125.24 | 14.46 | 3.93 |
| **2001** | 1209.82 | 8.19 | 0.153 | 1460.07 | 9.19 | 137.79 | 15.64 | 4.49 |
| **2002** | 1182.77 | 7.90 | 0.152 | 1425.49 | 8.53 | 133.00 | 15.32 | 3.81 |
| **2003** | 1268.75 | 8.11 | 0.160 | 1519.40 | 9.72 | 140.02 | 16.14 | 3.76 |
| **2004** | 1318.31 | 8.35 | 0.172 | 1578.26 | 9.76 | 141.20 | 16.50 | 3.65 |
| **2005** | 1292.72 | 8.24 | 0.177 | 1551.44 | 9.34 | 143.32 | 16.59 | 3.67 |
| **2006** | 1354.01 | 7.91 | 0.188 | 1607.75 | 9.31 | 139.15 | 16.17 | 3.42 |
| **2007** | 1370.96 | 7.96 | 0.197 | 1628.45 | 8.91 | 136.13 | 16.04 | 3.06 |
| **2008** | 1292.32 | 7.07 | 0.175 | 1521.25 | 8.06 | 132.07 | 14.95 | 2.45 |
| **2009** | 1279.73 | 7.68 | 0.185 | 1526.81 | 8.23 | 145.13 | 16.34 | 2.57 |
| **2010** | 1458.28 | 6.32 | 0.180 | 1670.09 | 8.17 | 111.95 | 12.85 | 2.28 |
| **2011** | 1355.77 | 6.20 | 0.181 | 1564.65 | 8.13 | 117.35 | 13.22 | 2.24 |
| **2012** | 1278.47 | 6.73 | 0.178 | 1499.67 | 7.94 | 117.79 | 13.63 | 2.17 |
| **2013** | 1247.42 | 6.13 | 0.174 | 1452.50 | 7.73 | 105.10 | 12.36 | 2.02 |
| **2014** | 1250.10 | 5.89 | 0.173 | 1448.92 | 7.76 | 98.03 | 11.47 | 1.95 |
| **Share of Energy total, 2014** | 19.1% | 47.3% | 46.9% | 20.8% | 26.1% | 77.3% | 53.1% | 49.1% |
| **2014 vs 2013** | 0.2% | -3.9% | -0.5% | -0.2% | 0.4% | -6.7% | -7.2% | -3.3% |
| **2014 vs 1990** | -77.7% | -33.3% | -30.3% | -75.4% | -65.6% | -39.8% | -32.6% | -94.4% |

GHG emissions in CRF 1.A.4 sector decreased by 78.3% in 1990-2000 due to reorganizations in the country after the collapse of Soviet Union, as mentioned in previous chapters (Table 3.42). Since 2000, GHG emissions started to grow due to thrive in national economy, and increased by 27.3% in until 2007. During economic crisis in 2008-2009 the emissions decreased by 6.2% from 2007, and increased in the following two years because of recovery in economy. However, in the recent years – 2012 and 2013 the GHG emissions decreased by 4.2% and 7.2% comparing with 2011 level – in 2012 a lot more biomass was used, and the use of solid fuels decreased significantly, whereas in 2013 gaseous fuels were used less than in 2012, and also the consumption of biomass reduced. In 2014 the GHG emissions are almost in the same level as in 2013. There can also be seen a trend that if the average temperature comparing with previous year has increased, $CO_2$ emissions are less and vice versa.

$CH_4$ and $N_2O$ emissions shows the biomass consumption trend – in 2012 the increase in emissions was 8.5% and decrease 1.6%, respectively, comparing with 2011, and in 2013 there can be seen a decrease in $CH_4$ and $N_2O$ emissions by 8.9% and 2.1%, comparing with 2012. A decrease in emissions can be seen also in 2014, comparing with 2013 – $CH_4$ emissions have decreased by 3.9%, and $N_2O$ emissions have a decrease by 0.5%.

Indirect GHG emissions from CRF 1.A.4 Other sectors were estimated as well. $SO_2$ had the biggest decrease by 94.4% in 1990–2014. It can be explained with fuel switching from coal, peat and heavy fuel oils to natural gas and biomass from what sulphur dioxide emissions are not emitted. Also a strict national legislation was approved to improve the quality of used liquid fuels in country. NOx emissions have also decreased by 65.6% in 1990-2014, NMVOC emissions – by 32.6%, and CO emissions – by 39.8%. The decrease can also be explained with fuel switch from solid to natural gas and biomass, which have lower emission factors.

#### 3.2.7.2 Methodological issues

*Methods*

2006 IPCC Guidelines' Tier 2 method was used to estimate $CO_2$ emissions from fuel combustion as country specific parameters were used to estimate $CO_2$ emission factor. However, for some fuels there are no country-specific emission factors, therefore 2006 IPCC Guidelines Tier 1 method using default emission factors was used. 2006 IPCC Guidelines' Tier 1 method was used to calculate $CH_4$ and $N_2O$ emissions from the CRF 1.A.4 sector.

Calculation of all emissions from fuel combustion is done with Excel databases developed by the experts from LEGMC.

The general method for emission data preparation was used:

$$Em = EF \times B_q$$

*where:*
*Em – total emissions (kt)*
*EF – estimated or default emission factor (t/TJ)*
*$B_q$ – amount of fuel in thermal units (TJ)*

*Emission factors and other parameters*

The main sources for emission factors are:

- National studies for country specific parameters and emission factors;
- Data from only natural gas supplier company of natural gas physical characteristics;
- IPCC 2006 Guidelines;
- EMEP/EEA 2013.

Country specific emission factors were used to calculate carbon dioxide ($CO_2$) and sulphur dioxide ($SO_2$) emissions.

**$CO_2$ emission factors**

$CO_2$ emission factors for CRF 1.A.4 Other sectors are estimated with the same equations and using same methods as for CRF 1.A.1 Energy industries sector, including calculation methods and assumptions for landfill gas and other biogas as in CRF 1.A.1 sector.

For some fuels default $CO_2$ emission factors from 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.4, were taken due to unavailability of country specific data:

- other liquid fuels – 73.3 kt/PJ;
- coal – 94.6 kt/PJ;
- biodiesel – 70.8 kt/PJ;
- straws – 100 kt/PJ;
- charcoal – 112 kt/PJ;
- waste oils – 73.3 kt/PJ.

For CRF 1.A.4.c.iii Fishing default $CO_2$ emission factors were taken from 2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Table 3.5.2:

- diesel oil – 74.1 kt/PJ;
- residual fuel oil – 77.4 kt/PJ.

**$SO_2$ emissions factors**

$SO_x$ emission factors for CRF 1.A.4 Other sectors are estimated with the same equations and using same method as for CRF 1.A.1 and CRF 1.A.2 sectors.

**Other emission factors**

The default $CH_4$ and $N_2O$ emission factors are taken from 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.3 (CRF 1.A.4.a, 1.A.4.c). For estimating $CH_4$ emissions from wood in CRF 1.A.4.b.i sector, Tier 2 approach with country specific EFs was used. These factors were obtained in a research "*Estimation of* $CH_4$ *and $N_2O$ emission factors for solid biomass, taking into account fuel and installation types*". $N_2O$ emission factors for wood products are taken from 2006 IPCC Guidelines, Chapter 2 *Stationary combustion*, Table 2.3. It has to be noted that for wood and charcoal the lowest $N_2O$ EFs were taken from the given range.

$NO_x$, CO and NMVOC emission factors used in estimation of emission were taken from EMEP/EEA 2013, Chapter 1.A.4 Small combustion, Tables 3-12 to 3-25 (CRF 1.A.4.b.i), Tables 3-7 to 3-10 (CRF 1.A.4.a.i, 1.A.4.c.i).

List of other emission factors can be seen in Table 3.43 and Table 3.44.

**Table 3.43 $CH_4$, $N_2O$, $NO_x$, NMVOC, CO emission factors in CRF 1.A.4.a and 1.A.4.c (kt/PJ)**

| | **$CH_4$** | | **$N_2O$** | **$NO_x$** | **NMVOC** | **CO** |
|---|---|---|---|---|---|---|
| | 1.A.4.a | 1.A.4.c | | | | |
| Diesel oil | 0.010 | 0.010 | 0.0006 | 0.513 | 0.03 | 0.066 |
| RFO | 0.010 | 0.010 | 0.0006 | 0.513 | 0.03 | 0.066 |
| LPG | 0.005 | 0.005 | 0.0001 | 0.074 | 0.023 | 0.029 |
| Jet fuel | 0.010 | 0.010 | 0.0006 | 0.513 | 0.03 | 0.066 |
| Other kerosene | 0.010 | 0.010 | 0.0006 | 0.513 | 0.03 | 0.066 |
| Other liquid | 0.010 | 0.010 | 0.0006 | 0.513 | 0.03 | 0.066 |
| Waste oils | 0.300 | 0.300 | 0.0040 | 0.513 | 0.03 | 0.066 |
| Shale oil | 0.010 | 0.010 | 0.0006 | 0.513 | 0.03 | 0.066 |
| Coal | 0.010 | 0.300 | 0.0015 | 0.173 | 0.089 | 0.931 |
| Peat briquettes | 0.010 | 0.300 | 0.0015 | 0.173 | 0.089 | 0.931 |
| Peat | 0.010 | 0.300 | 0.0015 | 0.173 | 0.089 | 0.931 |
| Natural gas | 0.005 | 0.005 | 0.0001 | 0.074 | 0.023 | 0.029 |
| Wood | 0.300 | 0.300 | 0.0040 | 0.091 | 0.300 | 0.570 |
| $CH_4$ from landfill gas | 0.005 | 0.005 | 0.0001 | 0.074 | 0.023 | 0.029 |
| Other biogas | 0.005 | 0.005 | 0.0001 | 0.074 | 0.023 | 0.029 |
| Straws | 0.300 | 0.300 | 0.0040 | 0.091 | 0.300 | 0.570 |
| Biodiesel | 0.010 | 0.010 | 0.0006 | 0.513 | 0.03 | 0.07 |
| Charcoal | 0.200 | 0.300 | 0.0040 | NO | NO | NO |

**Table 3.44 $CH_4$, $N_2O$, $NO_x$, NMVOC, CO emission factors in CRF 1.A.4.b (kt/PJ)**

| | | $CH_4$ | $N_2O$ | $NO_x$ | NMVOC | CO |
|---|---|---|---|---|---|---|
| | | kt/PJ | | | | |
| Diesel oil | | 0.01 | 0.0006 | 0.069 | 0.00017 | 0.0037 |
| RFO | | 0.01 | 0.0006 | 0.069 | 0.00017 | 0.0037 |
| LPG | | 0.005 | 0.0001 | 0.042 | 0.0018 | 0.022 |
| Other kerosene | | 0.01 | 0.0006 | 0.069 | 0.00017 | 0.0037 |
| Coal | | 0.3 | 0.0015 | 0.158 | 0.174 | 4.787 |
| Peat briquettes | | 0.3 | 0.0015 | 0.158 | 0.174 | 4.787 |
| Peat | | 0.3 | 0.0014 | 0.158 | 0.174 | 4.787 |
| Natural gas | | 0.005 | 0.0001 | 0.042 | 0.0018 | 0.022 |
| Wood | Central heating boilers | 0.361 | 0.0015 | 0.080 | 0.350 | 4.000 |
| | Hot water boilers | 0.009 | 0.0015 | 0.080 | 0.350 | 4.000 |
| | Combination boilers - central heating and hot water boilers | 0.131 | 0.0015 | 0.080 | 0.350 | 4.000 |
| | Room furnaces | 0.099 | 0.0015 | 0.080 | 0.350 | 4.000 |
| | Economic furnaces | 0.097 | 0.0015 | 0.095 | 0.250 | 2.000 |
| | Kitchen stoves | 0.083 | 0.0015 | 0.050 | 0.600 | 4.000 |
| | Pellet stoves | IE | IE | 0.080 | 0.010 | 0.300 |
| Straws | | 0.3 | 0.004 | 0.050 | 0.600 | 4.000 |
| Charcoal | | 0.2 | 0.0003 | 0.050 | 0.600 | 4.000 |

Gasoline emission factors are used for $CH_4$ and $N_2O$ emission estimation from off-roads (2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Table 3.3.1.). As there is no information about distribution between 2-stroke and 4-stroke engines, it was assumed that 25% of consumed gasoline is combusted in 2-stroke engines, while 75% - in 4-stroke engines. Such assumption has been made, based on Danish data which are presented in EMEP/EEA 2013 for air pollutants' calculations. The emission factors for indirect GHGs were taken from Chapter 1.A.4. Non-road mobile sources and machinery. $NO_x$, CO and NMVOC emission factors used in estimation of emission were taken from EMEP/EEA 2013, Chapter 1.A.4 Non-road mobile sources and machinery, Table 3-1.

Also diesel oil and residual fuel oil consumed in Fisheries sector was assumed as consumed by fishing ships and the emission factors were taken from 2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Table 3.5.2. Emission factors for indirect GHGs are taken from EMEP/EEA 2013, Chapter 1.A.3.d., Table 3-1.

Emission factors for gasoline consumed in Offroads and diesel oil and residual fuel oil consumed in Fisheries are presented in Table 3.45.

**Table 3.45 $CH_4$, $N_2O$, $NO_x$, NMVOC, CO emission factors for gasoline, diesel and RFO (kg/Mg[21])**

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">Gasoline</th><th rowspan="2">Diesel</th><th colspan="2">Offroad Diesel</th><th rowspan="2">RFO</th></tr>
<tr><th>2-stroke</th><th>4-stroke</th><th>Agriculture</th><th>Forestry</th></tr>
<tr><td rowspan="4">$CH_4$</td><td>1.A.4.a.ii</td><td>0.18</td><td>0.12</td><td rowspan="3">NO</td><td>NO</td><td>NO</td><td rowspan="3">NO</td></tr>
<tr><td>1.A.4.b.ii</td><td>0.18</td><td>0.12</td><td>NO</td><td>NO</td></tr>
<tr><td>1.A.4.c.ii</td><td>0.17</td><td>0.08</td><td>0.00415</td><td>0.00415</td></tr>
<tr><td>1.A.4.c.iii</td><td>NO</td><td>NO</td><td>0.007</td><td>NO</td><td>NO</td><td></td></tr>
<tr><td rowspan="3">$N_2O$</td><td>1.A.4.a.ii</td><td rowspan="3">0.0004</td><td rowspan="3">0.002</td><td rowspan="3">NO</td><td>NO</td><td>NO</td><td rowspan="3">NO</td></tr>
<tr><td>1.A.4.b.ii</td><td>NO</td><td>NO</td></tr>
<tr><td>1.A.4.c.ii</td><td>0.286</td><td>0.286</td></tr>
</table>

[21] *For $CH_4$ and $N_2O$ – kt/PJ*

| | | Gasoline | | Diesel | Offroad Diesel | | RFO |
|---|---|---|---|---|---|---|---|
| | | 2-stroke | 4-stroke | | Agriculture | Forestry | |
| | 1.A.4.c.iii | NO | NO | 0.002 | NO | NO | |
| $NO_x$ | 1.A.4.a.ii | 2.765 | 7.117 | NO | NO | NO | NO |
| | 1.A.4.b.ii | | | | NO | NO | |
| | 1.A.4.c.ii | | | | 35.043 | 29.093 | |
| | 1.A.4.c.iii | NO | NO | 78.5 | NO | NO | 79.3 |
| NMVOC | 1.A.4.a.ii | 242.197 | 17.602 | NO | NO | NO | NO |
| | 1.A.4.b.ii | | | | NO | NO | |
| | 1.A.4.c.ii | | | | 3.366 | 2.02 | |
| | 1.A.4.c.iii | NO | NO | 2.8 | NO | NO | 2.7 |
| CO | 1.A.4.a.ii | 620.739 | 770.368 | NO | NO | NO | NO |
| | 1.A.4.b.ii | | | | NO | NO | |
| | 1.A.4.c.ii | | | | 10.939 | 7.834 | |
| | 1.A.4.c.iii | NO | NO | 7.4 | NO | NO | 7.4 |

*Activity data*

Mainly emissions from fuel combustion are calculated using fuel consumption data from the national Energy Balance, prepared by CSB. The data collection system for CRF 1.A.4 sector is the same as for CRF 1.A.1 and CRF 1.A.2 sectors. Data on fuel consumption in 1.A.4 sector are presented in Annex A.3.1.

Autoproducers data prepared by CSP are taken into account into the calculation of the emissions from CRF 1.A.4 sector according to 2006 IPCC Guidelines.

Only gasoline combustion is reported as off-roads in CRF 1.A.4 sector. It is sure that diesel oil is also consumed as off-roads but for now it is not possible for CSB and LEGMC to divide the consumption between fuel combusted stationary and filled in technological vehicles. Due to that all diesel oil reported in the sector is estimated as combusted stationary.

In CRF 1.A.4.c.iii Fishing it is assumed, that diesel oil and residual fuel oil is consumed by fishing vessels.

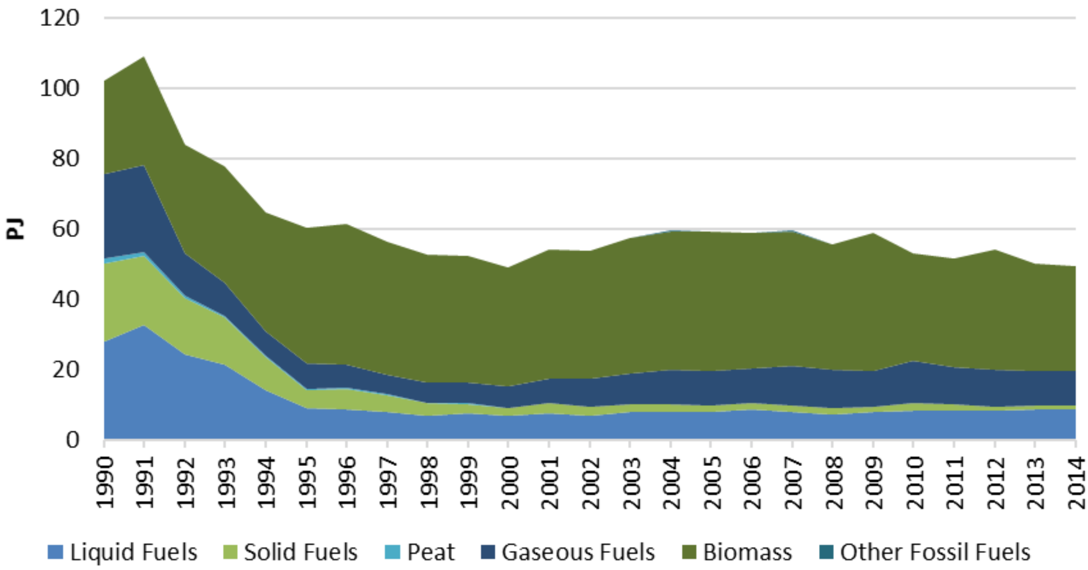


**Figure 3.43 Fuel consumption in Other sectors (CRF 1.A.4) for 1990-2014 (PJ)**

The biggest decrease in 1990-2014 was for solid fuel consumption – 95.7% and liquid fuels consumption – 68.5% (Figure 3.43). It is explained with fuel switching processes when solid and liquid fuels were replaced with cheaper fuels. Also stronger legislation contributed fuel switching to the type of fuels with a lower level of emissions.

Since 1990 biomass dominates as a fuel in CRF 1.A.4 sector. The biggest part of solid biomass consumption goes to Residential sector where biomass is the main fuel in small capacity burning installations. Consumption of biomass fuel has increased by 13% in 1990–2014 in Other sectors. However, it can be seen that the amounts of biomass have been fluctuating over recent years which can mainly be explained with temperature fluctuations during winter.

Since 1997 gaseous fuel consumption was constantly increasing until 2007, because it had lower costs to and liquid and solid fuels were replaced with natural gas as a fuel. The increase in fuel consumption in CRF 1.A.4 Other sectors is strongly linked to decrease in fuel consumption in CRF 1.A.1 Energy industries when central heating supply consumers switched to individual heating supply. In the recent years a decreased consumption in natural gas is observed, which was influenced by increasing costs of natural gas.

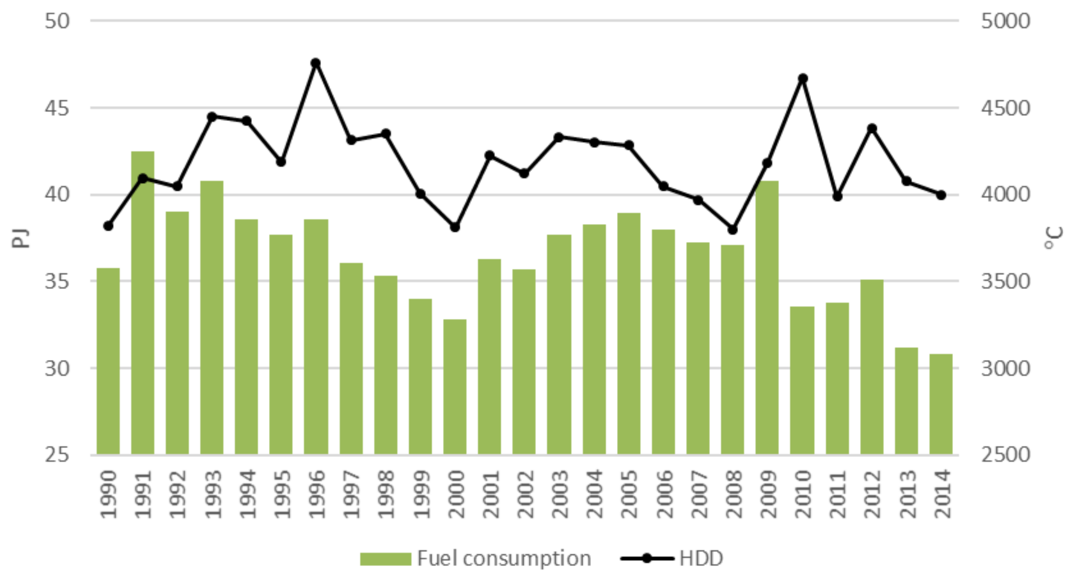


**Figure 3.44 Fuel consumption in Residential sector (CRF 1.A.4.b) for stationary combustion and heating degree days in Latvia**

As it can be seen in Figure 3.44, fuel consumption in 1.A.4.b sector is related with changes in temperature – in years where heating degree days are more, the amounts of consumed fuel are also larger, especially it can be seen in 1994-2003 and in the most recent years. In 2008 there was considerably low number of HDDs, and also the fuel consumed was less than in 2007. However, in 2009-2010 the correlation between HDDs and consumption is less visible because of impact of global crisis, which clearly affected the Residential sector. In 2011-2013 there can be seen a correlation in HDDs and fuel consumption – in 2012 the number of HDDs was by 9.9% higher than in 2011, and the amounts of fuel consumed were by 5% more. In 2013 the number of HDDs was by 7% less, and also fuel consumed was by 7% less than in 2012. In 2014 the number of HDDs was 2% less while the consumption of fuels was 1.2% less.

#### 3.2.7.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty in activity data of fuel combustion in 1.A.4 sector is ±2% in 2014. CSB gives approximately 2% statistical sample error for statistical data. According to CSB, as data are obtained using information given by respondents, this number is a variation coefficient which characterizes selection of respondents. Total variation coefficient for energy balance is within 2-3%. In Latvia all fossil fuels (oil, natural gas and coal) are imported and import and export statistics are fairly accurate.

Uncertainty of activity data for solid biomass combustion was assigned as 5% because biomass activity data were collected by CSB with questionnaires sent by enterprises consumed biomass. As fuel consumption in CRF 1.A.4.b Residential sector is obtained only every 5 years using questionnaire and data are extrapolated until the next survey, therefore the uncertainty of all fuel consumption in residential sector is assumed 15%. According to 2006 IPCC Guidelines, Volume 2, Chapter 1, pg. 1.19, biomass data are generally more uncertain than other data in national energy statistics, because a large fraction of the biomass may be part of the informal economy, and the trade in these type of fuels is frequently not registered in the national energy statistics and balances. Uncertainty of landfill gas stationary combusted in enterprises covered by 1.A.4 Other sectors was assumed rather low – 2% because the combusted fuel amount is obtained directly from landfill plant that has precise measurement equipment for accounting of combusted fuel. Still the methane percentage amount in combusted landfill gas is given approximately, therefore final uncertainty of biomass fuels is assumed as 5%.

$CO_2$ emission factor was estimated according physical characterization of used fuels in country basing on average NCV reported by fuel consumers and carbon content, hence the uncertainty for liquid fuels was assigned as quite low – about 10%. The same level of uncertainty was assigned for solid fuels. $CO_2$ emission factor for natural gas was assumed rather low – as 5% because annual plant specific fuel data is used to estimate emission factor.

$CH_4$ and $N_2O$ emission factor used in estimation of emissions was taken according to 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.12., which provides the range of default values for uncertainties. The uncertainty both for $CH_4$ and $N_2O$ EFs was assigned as uncertainties used in previous submissions – 50%.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. Emissions from all sectors are estimated or reported as not occurring / not applicable, therefore there are no "not estimated" sectors.

#### 3.2.7.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the Energy sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

All documentation and information received for inventory purposes are archived in FTP folder. All findings are documented by using check-lists, available on Regulations of the Cabinet of Ministers No. 217 adopted on 27 March 2012 "The National Inventory System of Greenhouse Gas Emission Units".

*Activity data verification*

All sources of energy data are presented in the corresponding NIR chapter (0 GHG emissions in CRF 1.A.4 sector decreased by 78.3% in 1990-2000 due to reorganizations in the country after the collapse of Soviet Union, as mentioned in previous chapters (Table 3.42). Since 2000, GHG emissions started to grow due to thrive in national economy, and increased by 27.3% in until 2007. During economic crisis in 2008-2009 the emissions decreased by 6.2% from 2007, and increased in the following two years because of recovery in economy. However, in the recent years – 2012 and 2013 the GHG emissions decreased by 4.2% and 7.2% comparing with 2011 level – in 2012 a lot more biomass was used, and the use of solid fuels decreased significantly, whereas in 2013 gaseous fuels were used less than in 2012, and also the consumption of biomass reduced.  In 2014 the GHG emissions are almost in the same level as in 2013. There can also be seen a trend that if the average temperature comparing with previous year has increased, $CO_2$ emissions are less and vice versa.

$CH_4$ and $N_2O$ emissions shows the biomass consumption trend – in 2012 the increase in emissions was 8.5% and decrease 1.6%, respectively, comparing with 2011, and in 2013 there can be seen a decrease in $CH_4$ and $N_2O$ emissions by 8.9% and 2.1%, comparing with 2012. A decrease in emissions can be seen also in 2014, comparing with 2013 – $CH_4$ emissions have decreased by 3.9%, and $N_2O$ emissions have a decrease by 0.5%.

Indirect GHG emissions from CRF 1.A.4 Other sectors were estimated as well. $SO_2$ had the biggest decrease by 94.4% in 1990–2014. It can be explained with fuel switching from coal, peat and heavy fuel oils to natural gas and biomass from what sulphur dioxide emissions are not emitted. Also a strict national legislation was approved to improve the quality of used liquid fuels in country. NOx emissions have also decreased by 65.6% in 1990-2014, NMVOC emissions – by 32.6%, and CO emissions – by 39.8%. The decrease can also be explained with fuel switch from solid to natural gas and biomass, which have lower emission factors.

Methodological issues) as well as disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1. Data completeness has been explained in the previous subchapter.

Activity data have been checked at the data provider – Central Statistical Bureau, which has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data have been received, the sectoral expert responsible for the emission estimation and reporting are comparing all data changes with the previous inventory, and all changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

All activity data used in Sectoral Approach are also compared with activity data used in Reference Approach estimations. All significant differences (±5%) are explained in the corresponding subchapter.

*Emission factor verification*

For country-specific $CO_2$ emission factors, the sources of the calorific values, carbon content and oxidation factors, as well as these values are provided in 0 GHG emissions in CRF 1.A.4 sector decreased by 78.3% in 1990-2000 due to reorganizations in the country after the collapse of Soviet Union, as mentioned in previous chapters (Table 3.42). Since 2000, GHG emissions started to grow due to thrive in national economy, and increased by 27.3% in until 2007. During economic crisis in 2008-2009 the emissions decreased by 6.2% from 2007, and increased in the following two years because of recovery in economy. However, in the recent years – 2012 and 2013 the GHG emissions decreased by 4.2% and 7.2% comparing with 2011 level – in 2012 a lot more biomass was used, and the use of solid fuels decreased significantly, whereas in 2013 gaseous fuels were used less than in 2012, and also the consumption of biomass reduced. In 2014 the GHG emissions are almost in the same level as in 2013. There can also be seen a trend that if the average temperature comparing with previous year has increased, $CO_2$ emissions are less and vice versa.

$CH_4$ and $N_2O$ emissions shows the biomass consumption trend – in 2012 the increase in emissions was 8.5% and decrease 1.6%, respectively, comparing with 2011, and in 2013 there can be seen a decrease in $CH_4$ and $N_2O$ emissions by 8.9% and 2.1%, comparing with 2012. A decrease in emissions can be seen also in 2014, comparing with 2013 – $CH_4$ emissions have decreased by 3.9%, and $N_2O$ emissions have a decrease by 0.5%.

Indirect GHG emissions from CRF 1.A.4 Other sectors were estimated as well. $SO_2$ had the biggest decrease by 94.4% in 1990–2014. It can be explained with fuel switching from coal, peat and heavy fuel oils to natural gas and biomass from what sulphur dioxide emissions are not emitted. Also a strict national legislation was approved to improve the quality of used liquid fuels in country. NOx emissions have also decreased by 65.6% in 1990-2014, NMVOC emissions – by 32.6%, and CO emissions – by 39.8%. The decrease can also be explained with fuel switch from solid to natural gas and biomass, which have lower emission factors.

Methodological issues.

Country specific $CO_2$ values for year are compared with default ones available on 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.2. Whether country specific $CO_2$ emission factor is or is not in the confidence interval, can be seen in Table 3.46.

**Table 3.46 Comparison of country specific and 2006 IPCC default $CO_2$ emission factor values (kt/PJ)**

| | Lower | CS | Upper | LV ETS |
|---|---|---|---|---|
| **Gasoline** | 67.50 | 71.18 | 73.00 | |
| **Diesel oil** | 72.60 | 74.00 | 74.80 | 74.75 |
| **RFO** | 75.50 | 76.59 | 78.80 | 77.36 |
| **LPG** | 61.60 | 62.44 | 65.60 | 62.75 |
| **Jet fuel** | 69.70 | 71.51 | 74.40 | |
| **Other kerosene** | 70.80 | 71.50 | 73.70 | |
| **Other liquid** | 72.20 | 72.59 | 74.40 | |
| **Shale oil** | 67.80 | 76.35 | 79.20 | 74.75 |

| | Lower | CS | Upper | LV ETS |
|---|---|---|---|---|
| **Peat** | 100.00 | 103.87 | 108.00 | 105.99 |
| **Natural gas** | 54.30 | 54.26 | 58.30 | 55.44 |
| **Wood** | 95.00 | 107.78 | 132.00 | |
| **Sludge gas** | 46.20 | 50.87 | 66.00 | |
| **Landfill gas** | 46.20 | 50.87 | 66.00 | |
| **Other biogas** | 46.20 | 50.87 | 66.00 | |

Only natural gas country specific $CO_2$ emission factor is outside of confidence interval given by 2006 IPCC Guidelines. Main reasons are different carbon content in fuel, as well as different NCVs.

*Emission verification:*

To verify the $CO_2$ emissions, logical mistakes are checked by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogical changes in the activity data and emissions. The emissions for indirect GHGs in the database are cross-checked with emissions reported within CLRTAP for verification purposes.

$CO_2$ emissions are compared with emissions in Reference Approach estimations, and all significant differences (±5%) are explained in the corresponding subchapter.

#### 3.2.7.5 Category-specific recalculations

Recalculations have been done in CRF 1.A.4.a sector due to activity data corrections. The largest recalculations have been done in CRF 1.A.4.b sector due to change of methodology from Tier 1 to Tier 2 as well as revised $CH_4$ and $N_2O$, and indirect GHGs' emission factors.

#### 3.2.7.6 Category-specific planned improvements

It is planned to update $CO_2$ EFs for most widely used fuels in Latvia and estimate life cycle of lubricants and used oils.

### 3.2.8 Other (CRF 1.A.5)

#### 3.2.8.1 Category description

Under the CRF 1.A.5.b Other Mobile sources emissions from liquid fuels – aviation gasoline, diesel oil and jet kerosene, used in military aircrafts and ships are reported. These emissions appear since 1996 (Table 3.47).

**Table 3.47 Emissions from Other sources (CRF 1.A.5) in 1990–2014 (kt)**

| | $CO_2$ | $CH_4$ | $N_2O$ | Aggregate GHGs | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|---|
| | kt | | | kt $CO_2$ eq. | kt | | | |
| **1990** | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE |
| **1991** | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE |
| **1992** | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE |
| **1993** | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE |
| **1994** | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE |

| | $CO_2$ | $CH_4$ | $N_2O$ | Aggregate GHGs | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|---|
| | kt | | | kt $CO_2$ eq. | kt | | | |
| **1995** | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE | NO,NE |
| **1996** | 0.19 | 1.36E-06 | 5.45E-06 | 0.19 | 2.48E-04 | 0.07 | 1.18E-03 | 1.9E-05 |
| **1997** | 0.10 | 6.82E-07 | 2.73E-06 | 0.10 | 1.24E-04 | 0.04 | 5.89E-04 | 9.3E-06 |
| **1998** | 0.19 | 1.36E-06 | 5.45E-06 | 0.19 | 2.48E-04 | 0.07 | 1.18E-03 | 1.9E-05 |
| **1999** | 0.15 | 1.08E-06 | 4.31E-06 | 0.15 | 1.96E-04 | 0.06 | 9.30E-04 | 1.5E-05 |
| **2000** | 0.14 | 9.67E-07 | 3.87E-06 | 0.14 | 1.76E-04 | 0.05 | 8.35E-04 | 1.3E-05 |
| **2001** | 0.17 | 1.19E-06 | 4.75E-06 | 0.17 | 2.16E-04 | 0.06 | 1.03E-03 | 1.6E-05 |
| **2002** | 6.88 | 5.32E-04 | 1.87E-04 | 6.95 | 0.14 | 0.54 | 0.013 | 7.8E-03 |
| **2003** | 6.16 | 4.61E-04 | 1.68E-04 | 6.22 | 0.12 | 0.55 | 0.013 | 6.9E-03 |
| **2004** | 9.63 | 7.86E-04 | 2.61E-04 | 9.73 | 0.21 | 0.57 | 0.016 | 1.1E-02 |
| **2005** | 7.62 | 5.53E-04 | 2.08E-04 | 7.70 | 0.14 | 0.75 | 0.017 | 8.4E-03 |
| **2006** | 7.51 | 5.27E-04 | 2.05E-04 | 7.59 | 0.14 | 0.83 | 0.018 | 8.0E-03 |
| **2007** | 2.84 | 1.12E-04 | 7.85E-05 | 2.87 | 0.03 | 0.70 | 0.012 | 2.5E-03 |
| **2008** | 3.41 | 1.58E-04 | 9.40E-05 | 3.44 | 0.04 | 0.73 | 0.013 | 2.0E-03 |
| **2009** | 5.34 | 3.55E-04 | 1.46E-04 | 5.39 | 0.09 | 0.67 | 0.014 | 3.4E-03 |
| **2010** | 7.87 | 6.17E-04 | 2.14E-04 | 7.95 | 0.16 | 0.58 | 0.015 | 5.0E-03 |
| **2011** | 7.22 | 5.71E-04 | 1.96E-04 | 7.29 | 0.15 | 0.51 | 0.013 | 4.6E-03 |
| **2012** | 7.33 | 5.61E-04 | 1.99E-04 | 7.40 | 0.15 | 0.60 | 0.014 | 4.7E-03 |
| **2013** | 6.45 | 4.56E-04 | 1.76E-04 | 6.51 | 0.12 | 0.69 | 0.015 | 4.1E-03 |
| **2014** | 9.44 | 7.50E-04 | 2.56E-04 | 9.54 | 0.20 | 0.65 | 0.017 | 6.0E-03 |
| **Share of Energy total, 2014** | 0.14% | 0.01% | 0.07% | 0.14% | 0.66% | 0.51% | 0.08% | 0.15% |
| **2014 vs 2013** | 46.4% | 64.3% | 45.9% | 46.5% | 64.8% | -5.7% | 13.6% | 46.2% |
| **2014 vs 1996** | 4848.1% | 54904.0% | 4603.6% | 4854.9% | 79382.4% | 774.3% | 1340.1% | 32275% |

Emissions from this sector are not influenced by the changes in national economy or in the economy of Latvia's trade partners, but still the emissions are decreasing since 2004. However, in the recent years until 2012 there has been an increase of fuel consumption, according to data given by CSB. In 2013 the GHG emissions decreased by 12% comparing with 2012. In 2014, GHG emissions increased by 46%, comparing with 2013.

#### 3.2.8.2 Methodological issues

*Methods*

2006 IPCC Guidelines' Tier 1 method was used to calculate GHG emissions from the 1.A.5.b Other Mobile source sector.

Calculations of all emissions from fuel combustion are done with Excel databases developed by experts from LEGMC.

The general method for preparing inventory data was used:

$$Em = EF \times B_q$$

*where:*
*Em – total emissions (kt)*
*EF – estimated or default emission factor (t/TJ)*
*$B_q$ – amount of fuel in thermal units (TJ)*

*Emission factors and other parameters*

Default emission factors for direct GHGs from Military aircrafts are taken from 2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Table 3.5.2 and Table 3.6.4 (Table 3.48).

Indirect GHGs emission factors were taken from EMEP/EEA 2013. Country specific emission factors were used to calculate sulphur dioxide ($SO_2$) emissions.

**Table 3.48 $CO_2$, $CH_4$, $N_2O$, NOx, NMVOC, CO emission factors[22]**

| | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | NMVOC | CO |
|---|---|---|---|---|---|---|
| **Aviation gasoline** | 69.3 | 0.0005 | 0.002 | 4 | 19 | 1200 |
| **Diesel oil** | 74.1 | 0.007 | 0.002 | 78.5 | 2.8 | 7.4 |
| **Jet fuel** | 71.5 | 0.0005 | 0.002 | 4 | 19 | 1200 |

### 3.2.8.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty in activity data of fuel combustion in sectors CRF 1.A.5.b is ±2% in 2014 because official statistical information from CSB is used.

Emission factors used for emission estimation were taken from 2006 IPCC Guidelines. For diesel oil the uncertainty for $CO_2$ emission factor, according to these Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Section 3.5.1.7, is 2%, but for $CH_4$ and $N_2O$ it is much higher - about 50%. For aviation gasoline and jet fuel, the uncertainty for $CO_2$ emission factor, according to 2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Section 3.6.1.7, is 5%, but for $CH_4$ and $N_2O$ it is assumed that the uncertainty is very high – 100%.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series.

### 3.2.8.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the Energy sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

All documentation and information received for inventory purposes are archived in FTP folder. All findings are documented by using check-lists, available on Regulations of the Cabinet of Ministers No. 217 adopted on 27 March 2012 "The National Inventory System of Greenhouse Gas Emission Units".

*Activity data verification*

[22] *Units for GHGs are in kt/PJ, for indirect GHGs in kg/Mg.*

All sources of energy data are presented in the corresponding NIR chapter (3.2.8.2 Methodological issues) as well as disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1. Data completeness has been explained in the previous subchapter.

Activity data have been checked at the data provider – Central Statistical Bureau, which has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data have been received, the sectoral expert responsible for the emission estimation and reporting are comparing all data changes with the previous inventory, and all changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

All activity data used in Sectoral Approach are also compared with activity data used in Reference Approach estimations. All significant differences (±5%) are explained in the corresponding subchapter.

*Emission factor verification*

As all emission factors are taken from 2006 IPCC Guidelines, no additional verification procedures have been performed.

*Emission verification*

To verify the $CO_2$ emissions, logical mistakes are checked by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogical changes in the activity data and emissions. The emissions for indirect GHGs in the database are cross-checked with emissions reported within CLRTAP for verification purposes.

$CO_2$ emissions are compared with emissions in Reference Approach estimations, and all significant differences (±5%) are explained in the corresponding subchapter.

#### 3.2.8.5 Category-specific planned recalculations

No recalculations are done in particular sector.

#### 3.2.8.6 Category-specific planned improvements

No improvements are planned to be done until the next submission.

## *3.3 FUGITIVE EMISSIONS FROM SOLID FUELS AND OIL AND NATURAL GAS (CRF 1.B)*

Under the 1.B Fugitive emissions category $CO_2$, $CH_4$ and NMVOC emissions from operations with natural gas and light liquid fuels are reported (Table 3.49).

**Table 3.49 Reported fugitive $CO_2$, $CH_4$, NMVOC emissions in Latvia in 1990-2014 (kt)**

| | $CO_2$ | $CH_4$ | Aggregate GHGs | NMVOC |
|---|---|---|---|---|
| | kt | kt | kt $CO_2$ eq. | kt |
| **1990** | 0.0115 | 9.90 | 247.59 | 4.18 |
| **1991** | 0.0111 | 9.54 | 238.49 | 3.88 |
| **1992** | 0.0101 | 8.70 | 217.43 | 3.59 |
| **1993** | 0.0097 | 8.32 | 207.94 | 3.45 |
| **1994** | 0.0094 | 8.13 | 203.20 | 3.35 |

| | $CO_2$ | $CH_4$ | Aggregate GHGs | NMVOC |
|---|---|---|---|---|
| | kt | kt | kt $CO_2$ eq. | kt |
| **1995** | 0.0092 | 7.92 | 197.89 | 3.19 |
| **1996** | 0.0089 | 7.63 | 190.68 | 3.10 |
| **1997** | 0.0083 | 7.12 | 177.96 | 2.88 |
| **1998** | 0.0079 | 6.83 | 170.75 | 2.75 |
| **1999** | 0.0076 | 6.51 | 162.79 | 2.63 |
| **2000** | 0.0070 | 6.03 | 150.64 | 2.48 |
| **2001** | 0.0073 | 5.84 | 146.09 | 2.47 |
| **2002** | 0.0074 | 6.10 | 152.57 | 2.52 |
| **2003** | 0.0055 | 4.76 | 119.08 | 2.12 |
| **2004** | 0.0055 | 4.71 | 117.87 | 2.11 |
| **2005** | 0.0062 | 5.33 | 133.19 | 2.28 |
| **2006** | 0.0044 | 3.82 | 95.53 | 1.91 |
| **2007** | 0.0046 | 3.92 | 98.07 | 2.72 |
| **2008** | 0.0047 | 4.03 | 100.70 | 2.50 |
| **2009** | 0.0044 | 3.81 | 95.13 | 2.44 |
| **2010** | 0.0043 | 3.66 | 91.61 | 2.35 |
| **2011** | 0.0054 | 2.52 | 63.03 | 1.40 |
| **2012** | 0.0049 | 3.18 | 79.61 | 1.44 |
| **2013** | 0.0080 | 4.04 | 101.01 | 1.71 |
| **2014** | 0.0138 | 5.41 | 135.33 | 2.34 |
| **Share of Energy total, 2014** | 0.0002% | 43.5% | 1.9% | 10.8% |
| **2014 vs 2013** | 72.2% | 34.0% | 34.0% | 37.0% |
| **2014 vs 1990** | 19.8% | -45.3% | -45.3% | -44.1% |

It is possible to get data from hard coal transportation via railways but it is assumed that no GHG emissions are generated during this activity. Only particulate matters emissions are estimated from coal transportation in Latvia.

There are lasting peat mining and manufacturing traditions in Latvia. As stated in 2006 IPCC Guidelines, Volume 4 *Agriculture, Forestry and Other Land Use*, Chapter 1 *Introduction*, with current state of scientific knowledge, it is possible to provide methods for estimating $CO_2$ and $N_2O$ emissions associated with management of peatlands, and $CO_2$ from conversion to wetlands by flooding. However, according to 2006 IPCC Guidelines, Volume 4, Chapter 7 *Wetlands*, all on-site sources of greenhouse gas emissions should be reported under AFOLU *Wetlands* category regardless of the end-use of peat.

There are no coal mines in Latvia and therefore no fugitive emissions from mining processes occur.

## 3.3.1 Fugitive emission from oil (CRF 1.B.2.a)

### 3.3.1.1 Category description

CRF sector 1.B.2.a Oil includes NMVOC emissions from refined oil products storage and distribution. There are no oil refineries in Latvia; therefore NMVOC emissions from gasoline distribution only were calculated for 1990–2014.

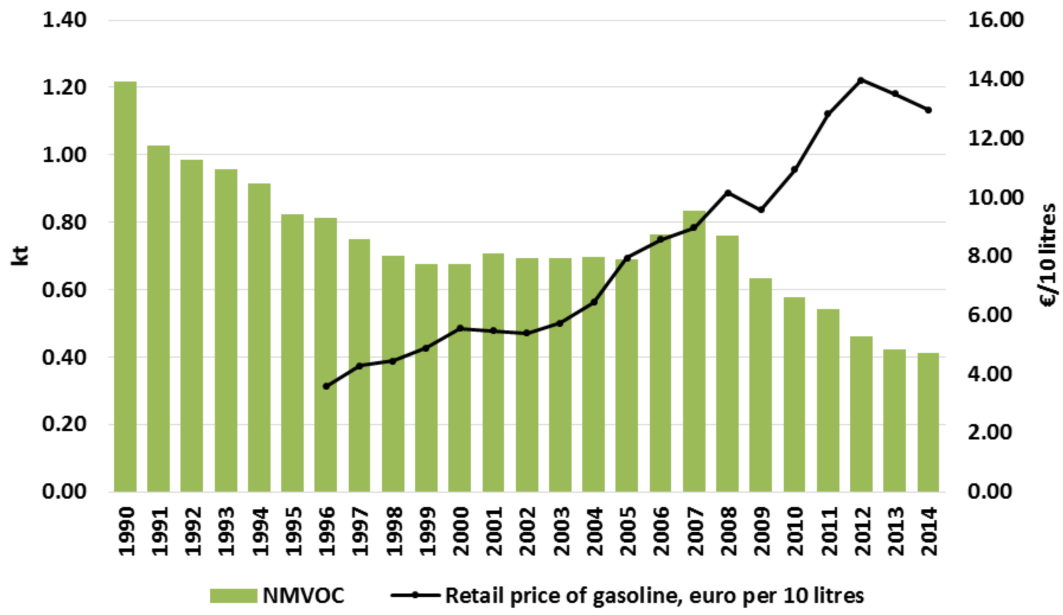


**Figure 3.45 Fugitive NMVOC emissions from oil products in 1990–2014 and retail price for gasoline in 1996-2014**

Decrease of NMVOC emissions in whole time series can be generally explained with increasing costs of gasoline therefore it was used less. In 2005-2007 there can be seen a rise in emissions which can be explained with economic growth and prosperity, however, in 2008 due to global crisis, the use of gasoline, as well as NMVOC emissions decreased, and continued to decrease after that because of rapid increase in retail price (Figure 3.45). Since 1990 up to 2014 the NMVOC emissions have decreased by 66%.

### 3.3.1.2 Methodological issues

Methods

EMEP/EEA 2013 Tier 1 methodology is used to estimate fugitive NMVOC emissions from operations with gasoline in 1990–2014. It uses the general equation, where emissions are obtained by multiplying the total amount of gasoline sold with the emission factor.

*Emission factors*

NMVOC emission factor – 2 kg/Mg oil – for emission from gasoline distribution was taken from EMEP/EEA 2013, Chapter 1.B.2.a.v Distribution of oil products, Table 3-1.

*Activity data*

Activity data for NMVOC emission calculation was used from CSB Energy Balance (Table 3.50).

**Table 3.50 Gasoline consumption in Latvia in 1990–2014 (TJ)**

| | |
|---|---|
| **1990** | 26796 |
| **1991** | 22616 |
| **1992** | 21692 |
| **1993** | 21032 |
| **1994** | 20108 |
| **1995** | 18128 |

| | |
|---|---|
| **1996** | 17908 |
| **1997** | 16456 |
| **1998** | 15400 |
| **1999** | 14872 |
| **2000** | 14831 |
| **2001** | 15535 |
| **2002** | 15228 |
| **2003** | 15214 |
| **2004** | 15346 |
| **2005** | 15126 |
| **2006** | 16753 |
| **2007** | 18299 |
| **2008** | 16672 |
| **2009** | 13941 |
| **2010** | 12667 |
| **2011** | 11926 |
| **2012** | 10146 |
| **2013** | 9282 |
| **2014** | 9018 |

#### 3.3.1.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Activity data for fugitive emissions from operations with gasoline were taken from CSB and uncertainty was assumed as very low for about 2% as statistical frame mistake. Uncertainty for emission factor is assumed as 100%, according to 2006 IPCC Guidelines, Volume 2, Chapter 4 *Fugitive emissions*, Table 4.2 (refined product distribution).

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. Emissions from all sectors are estimated or reported as not occurring / not applicable therefore there are no "not estimated" sectors.

#### 3.3.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the Energy sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

All documentation and information received for inventory purposes are archived in FTP folder. All findings are documented by using check-lists, available on Regulations of the Cabinet of Ministers No. 217 adopted on 27 March 2012 "The National Inventory System of Greenhouse Gas Emission Units".

*Activity data verification*

All sources of energy data are presented in the corresponding NIR chapter (3.3.1.2 Methodological issues) as well as disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1. Data completeness has been explained in the previous subchapter.

Activity data have been checked at the data provider – Central Statistical Bureau, which has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data have been received, the sectoral expert responsible for the emission estimation and reporting are comparing all data changes with the previous inventory, and all changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

*Emission factor verification*

As all emission factors are taken from EMEP/EEA 2013, no additional verification procedures have been performed.

*Emission verification*

To verify the NMVOC emissions, logical mistakes are checked by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogical changes in the activity data and emissions. The emissions are also cross-checked with emissions reported within CLRTAP for verification purposes.

#### 3.3.1.5 Category-specific recalculations

No recalculations are done in the particular subsector.

#### 3.3.1.6 Category-specific planned improvements

No improvements are planned to be done until the next submission.

### 3.3.2 Fugitive emissions from natural gas (CRF 1.B.2.b, CRF 1.B.2.c, CRF 1.B.2.d)

#### 3.3.2.1 Category description

$CO_2$, $CH_4$ and NMVOC emissions from operations with natural gas are reported in the following sub-sectors CRF 1.B.2.b Natural gas sector:

- 1.B.2.b.i Venting;
- 1.B.2.b.iii All other:
    - 1.B.2.b.iii 4 Transmission and storage;
    - 1.B.2.b.iii 5 Distribution;
    - 1.B.2.b.iii 6 Other (includes leakage at industrial plants and power stations and leakage at residential and commercial sectors)

**Table 3.51 Fugitive $CH_4$, $CO_2$ and NMVOC emissions from natural gas 1990-2014 (kt)**

| | $CO_2$ | $CH_4$ | Aggregate GHGs | NMVOC |
|---|---|---|---|---|
| | kt | | kt $CO_2$ eq. | kt |
| **1990** | 0.0115 | 9.90 | 247.59 | 2.97 |
| **1991** | 0.0111 | 9.54 | 238.49 | 2.86 |
| **1992** | 0.0101 | 8.70 | 217.43 | 2.60 |
| **1993** | 0.0097 | 8.32 | 207.94 | 2.49 |

| | $CO_2$ | $CH_4$ | Aggregate GHGs | NMVOC |
|---|---|---|---|---|
| | kt | | kt $CO_2$ eq. | kt |
| **1994** | 0.0094 | 8.13 | 203.20 | 2.43 |
| **1995** | 0.0092 | 7.92 | 197.89 | 2.37 |
| **1996** | 0.0089 | 7.63 | 190.68 | 2.28 |
| **1997** | 0.0083 | 7.12 | 177.96 | 2.13 |
| **1998** | 0.0079 | 6.83 | 170.75 | 2.05 |
| **1999** | 0.0076 | 6.51 | 162.79 | 1.95 |
| **2000** | 0.0070 | 6.03 | 150.64 | 1.80 |
| **2001** | 0.0073 | 5.84 | 146.09 | 1.76 |
| **2002** | 0.0074 | 6.10 | 152.57 | 1.83 |
| **2003** | 0.0055 | 4.76 | 119.08 | 1.43 |
| **2004** | 0.0055 | 4.71 | 117.87 | 1.41 |
| **2005** | 0.0062 | 5.33 | 133.19 | 1.60 |
| **2006** | 0.0044 | 3.82 | 95.53 | 1.14 |
| **2007** | 0.0046 | 3.92 | 98.07 | 1.89 |
| **2008** | 0.0047 | 4.03 | 100.70 | 1.74 |
| **2009** | 0.0044 | 3.81 | 95.13 | 1.81 |
| **2010** | 0.0043 | 3.66 | 91.61 | 1.77 |
| **2011** | 0.0054 | 2.52 | 63.03 | 0.86 |
| **2012** | 0.0049 | 3.18 | 79.61 | 0.98 |
| **2013** | 0.0080 | 4.04 | 101.01 | 1.28 |
| **2014** | 0.0138 | 5.41 | 135.33 | 1.93 |
| **Share of Energy total, 2014** | 0.0002% | 43.5% | 1.9% | 8.9% |
| **2014 vs 2013** | 72.2% | 34.0% | 34.0% | 50.2% |
| **2014 vs 1990** | 19.8% | -45.3% | -45.3% | -35.0% |

The emissions have a decreasing trend in 1990-2014 with the reduction of GHGs by 45%. There are few years where the emissions increased, and in all cases the increase is related with repair works and modernisation of existing pipeline system. In 2014, there can be seen a rise in emissions by 115% comparing with 2011, and it can be explained with repair works in pipeline system. However, a detailed information about length of pipelines, materials used for the distribution network, pressure conditions, flow rates etc. is not possible to obtain due to confidentiality issues because "Latvijas Gāze" is the only company in Latvia which distributes natural gas.

### 3.3.2.2 Methodological issues

Methods

LEGMC are receiving data about $CH_4$ emissions from the natural gas holding company "Latvijas Gāze" for the time period 1990–2014, Consequently company "Latvijas Gāze" calculates emissions by itself, using data of natural gas density and other physical parameters, and measures the content of methane and other chemical compounds in natural gas, therefore it is assumed as Tier 2 method, using country-specific data and calculations.

LEGMC has methodological material, which describes how the amounts of natural gas leaked are calculated. The methodology is translated in English and a brief essence of methods is available on Annex 3.4.

Activity data

$CH_4$ emissions are obtained from the holding company "Latvijas Gāze" and the activity data (millions $m^3$) are provided in Table 3.52.

**Table 3.52 Amounts of natural gas leaked in 1990-2014 ($10^6$ $m^3$)**

| | 1.B.2.b.i Venting | 1.B.2.b.iii 4 Transmission and storage | 1.B.2.b.iii 5 Distribution | 1.B.2.b.iii 6 Other | Total |
|---|---|---|---|---|---|
| **1990** | 5.61 | 0.13 | 0.69 | 12.44 | 18.87 |
| **1991** | 5.38 | 0.13 | 0.69 | 11.98 | 18.17 |
| **1992** | 4.83 | 0.13 | 0.59 | 10.92 | 16.47 |
| **1993** | 4.58 | 0.13 | 0.69 | 10.44 | 15.85 |
| **1994** | 4.46 | 0.13 | 0.69 | 10.21 | 15.48 |
| **1995** | 4.32 | 0.13 | 0.69 | 9.94 | 15.08 |
| **1996** | 4.13 | 0.13 | 0.69 | 9.58 | 14.53 |
| **1997** | 3.80 | 0.13 | 0.69 | 8.94 | 13.56 |
| **1998** | 3.63 | 0.11 | 0.69 | 8.58 | 13.01 |
| **1999** | 3.42 | 0.11 | 0.69 | 8.18 | 12.40 |
| **2000** | 3.11 | 0.11 | 0.69 | 7.57 | 11.48 |
| **2001** | 0.30 | 0.10 | 0.69 | 10.03 | 11.14 |
| **2002** | 0.98 | 0.10 | 0.69 | 9.86 | 11.63 |
| **2003** | 1.09 | 0.10 | 0.69 | 7.20 | 9.07 |
| **2004** | 1.56 | 0.09 | 0.69 | 6.63 | 8.98 |
| **2005** | 3.25 | 0.09 | 0.69 | 6.12 | 10.15 |
| **2006** | 1.80 | 0.08 | 0.69 | 4.71 | 7.28 |
| **2007** | 1.76 | 0.07 | 0.69 | 4.95 | 7.47 |
| **2008** | 2.44 | 0.07 | 0.69 | 4.48 | 7.67 |
| **2009** | 1.78 | 0.06 | 0.69 | 4.71 | 7.25 |
| **2010** | 1.64 | 0.06 | 0.69 | 4.59 | 6.98 |
| **2011** | 1.77 | 0.05 | 0.69 | 1.70 | 4.21 |
| **2012** | 1.34 | 0.05 | 0.69 | 3.35 | 5.43 |
| **2013** | 1.09 | 0.04 | 0.69 | 4.06 | 5.89 |
| **2014** | 1.53 | 0.04 | 0.66 | 5.69 | 7.93 |

#### 3.3.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The level of uncertainty was determined by natural gas distributing company „Latvijas Gāze". The uncertainty both for activity data (gas amounts) and $CH_4$, $CO_2$ and NMVOC emissions from gas venting and natural gas leakages in gas distribution and transmission systems, as well as in gas storage facility is assigned as quite low – 10%, as these were estimated by only enterprise operated with natural gas in Latvia – "Latvijas Gāze" by methodology developed for enterprise. However, for other leakage (CRF 1.B.2.b.iii 6) the uncertainty for the emissions is assumed as 35%.

Emissions from all sectors are estimated or reported as not occurring / not applicable therefore there are no "not estimated" sectors.

#### 3.3.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the Energy sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

"Latvijas Gāze", that reports fugitive $CH_4$ emissions from the operations with natural gas, estimates $CH_4$ and $CO_2$ emissions according to methodology prepared especially for the organization that is internationally verified and approved by the Environment State Bureau. Underground storage "Inčukalns" also has an ISO standard and all the information obtaining procedures are controlled and verified.

#### 3.3.2.5 Category-specific recalculations

No recalculations are done in the particular subsector.

#### 3.3.2.6 Category-specific planned improvements

No improvements are planned to be done until the next submission.

## *3.4 $CO_2$ TRANSPORT AND STORAGE (CRF 1.C)*

There is no $CO_2$ captured and further storaged in Latvia. There is a research done to find the potential sites for $CO_2$ geological storage in Latvia within international project "Assessing European Capacity for Geological Storage of Carbon Dioxide" (EU GeoCapacity)[23,24]. Latvia has a storage potential in local structures in the Cambrian water-saturated sandstone. In one of such geological structures, an underground storage of natural gas was established already in 1968 – the Inčukalns natural gas storage. For modelling the potential costs, the largest $CO_2$ source in Latvia in 2005 from ETS was taken, and as potential storages were selected the two largest ones. The modelling results demonstrated that the efficiency of the establishment of $CO_2$ storages there is too low. The unsatisfactory results are associated with the inefficient injection of small volumes of $CO_2$ in the storages, and the cost of the establishment of infrastructure is quite high, and the expenditure is unfounded with the low level of $CO_2$ injection.

[23] *http://www.co2geonet.com/NewsData.aspx?IdNews=44&ViewType=Old&IdType=18*
[24] *http://meteo.lv/fs/CKFinderJava/userfiles/files/Geologija/Potential%20sites.pdf*

# 4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF 2)

## *4.1 OVERVIEW OF SECTOR*

Greenhouse gas emissions from Industrial Processes and Product Use (IPPU) contributed 7.4% to the total anthropogenic greenhouse gas emissions excluding LULUCF in 2014 (Figure 4.1) totalling 837 kt $CO_2$ eq.

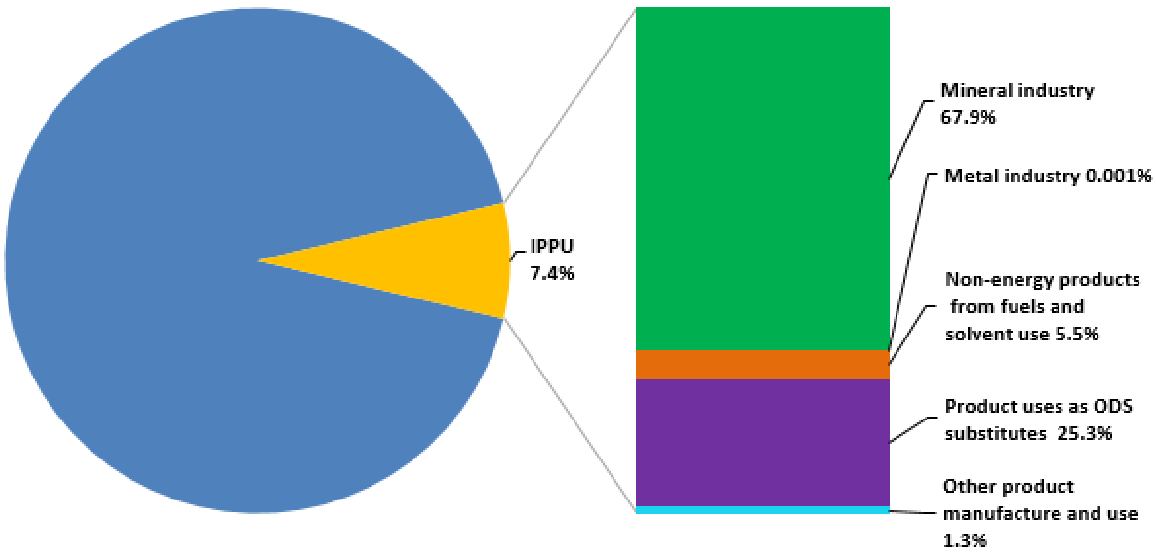


**Figure 4.1 Emissions from the industrial processes and product use sector compared with the total emissions in 2014**

The majority (67.9%) of IPPU emissions originate in 2.A Mineral industry ($CO_2$ emissions from Cement and Lime production, Other process uses of carbonates and Glass production). The second largest emission category under IPPU sector is 2.F Product uses as substitutes for ODS constituting 25.3% from IPPU emissions and 1.9% from total GHG emissions in Latvia (excluding LULUCF). Almost all 2.F. emissions comes from 2.F.1 Refrigeration and air conditioning appliances. Remaining sectors generating emissions in IPPU are 2.D Non-energy products from fuels and solvent use (5.5%) and 2.G Other product manufacture and use constituting 1.3% from total IPPU emissions in 2014.

Sources of emissions from IPPU sector reported in Latvia`s GHG inventory are as follows:

- Mineral Industry (CRF 2.A)
  - Cement Production (clinker production) (CRF 2.A.1)
  - Lime Production (as non-marketed lime for steel production in Iron & Steel production plant) and limestone and dolomite use in lime production (CRF 2.A.2)
  - Glass Production (CRF 2.A.3)
    - Raw material use in glass production – potash, fluorspar and witherite
    - Limestone and dolomite use in glass production
    - NMVOCs and indirect $CO_2$ from glass fibre production
    - Soda ash use in glass production
  - Other Process Uses of Carbonates (CRF 2.A.4)

        - Ceramics (Bricks and tiles production) (CRF 2.A.4.a)
        - Other (NOx, CO and NMVOC emissions from clinker production) (CRF 2.A.4.d)
- Metal Industry (CRF 2.C)
    - Iron and Steel Production (CRF 2.C.1)
        - $CO_2$ emissions from use of crude iron as raw material
        - $CH_4$ and indirect GHG emissions from total iron and steel production
        - $CO_2$ emissions from limestone and dolomite use in steel production
- Non-energy products from fuels and solvent use (CRF 2.D)
    - Lubricant Use (CRF 2.D.1)
    - Paraffin Wax Use (CRF 2.D.2)
    - Other (CRF 2.D.3)
        - Solvent use
        - Road paving with asphalt
        - Asphalt roofing
        - Urea use
- Product uses as Substitutes for ODS (CRF 2.F)
    - Refrigeration and Air Conditioning (CRF 2.F.1)
        - Commercial Refrigeration (CRF 2.F.1.a)
        - Domestic Refrigeration (CRF 2.F.1.b)
        - Industrial Refrigeration (CRF 2.F.1.c)
        - Transport Refrigeration (CRF 2.F.1.d)
        - Mobile Air-Conditioning (CRF 2.F.1.e)
        - Stationary Air-Conditioning (CRF 2.F.1.f)
    - Foam Blowing Agents (CRF 2.F.2)
        - Closed Cells (CRF 2.F.2.a)
    - Fire Protection (CRF 2.F.3)
    - Aerosols (CRF 2.F.4)
        - Metered Dose Inhalers (CRF 2.F.4.a)
- Other product manufacture and use (CRF 2.G)
    - Electrical Equipment (CRF 2.G.1)
    - $N_2O$ From Product Uses (CRF 2.G.3)
- Other Production (CRF 2.H)
        - NMVOC emissions from food and drink production (2.H.1)
        - $CO_2$ emissions from limestone use in sugar production for time period 2005-2006 (2.H.1)
        - $SO_2$ emissions from Pulp and Paper production for time period 1990 – 1996 (2.H.2).

Emissions from the Chemical Industry (CRF 2.B) and Electronics Industry (CRF 2.E) are not occurring (NO) in Latvia. In CRF Reporter some information and data in the parent categories (green and grey cells) in corresponding CRF tables might be missing due to CRF internal issue which does not allow to directly enter NO in green and grey cells without adding child nodes. It was confirmed by CRF help desk that this issue be improved in the future releases of the software.

### 4.1.1 Description

Emissions from IPPU have been increased by 18.3% since 1990 (Figure 4.2, Table 4.1). IPPU emissions in 2014 increased by 1% compared to 2013.

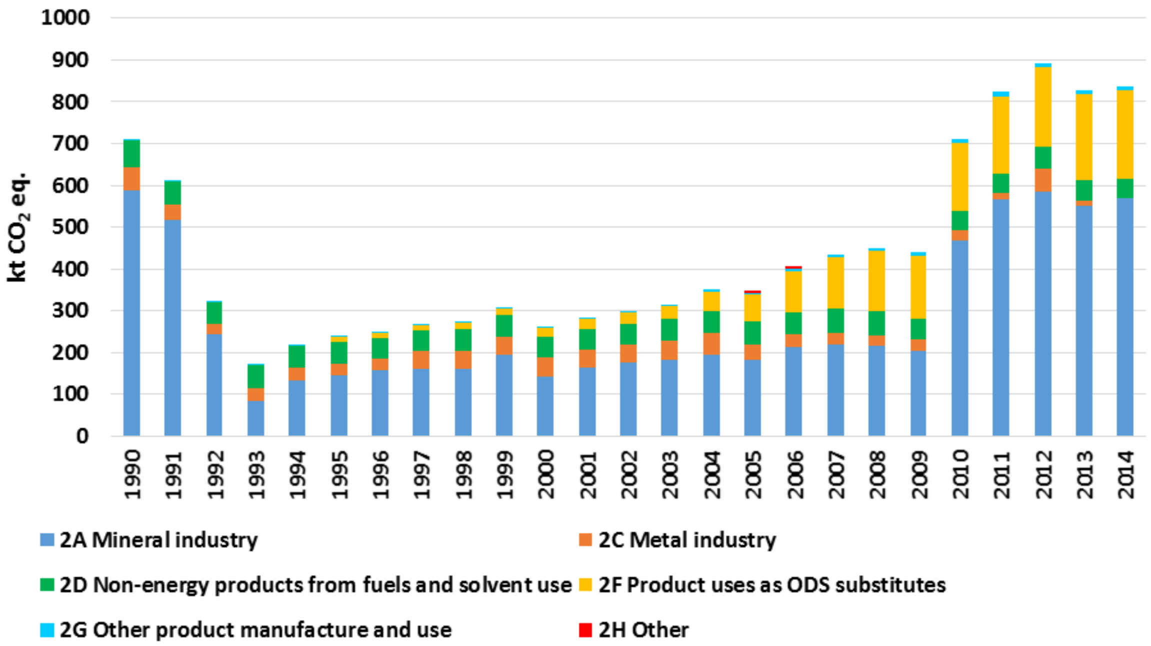


**Figure 4.2 GHG emissions from Industrial Processes and Product Use in 1990–2014 (kt $CO_2$ eq.)**

Emission fluctuations through years are mainly linked with the economic situation in the country. The largest decrease in emissions occurred between years 1991 and 1993, when industry was affected by a crisis. It has to be noted that at the beginning of 1990s during the countrywide change in government system the national economy statistics was not well kept. Therefore there is a lack of statistical data regarding industry during this time period or they are vague. The data extrapolation was carried out for the sectors where it was possible.

A key drivers for IPPU emission growth starting from 1994 are overall increase of activity in industrial production processes (cement and lime production). Since that time sharp development of construction activities has been observed and industrial production of building materials also increased. Changes in export of products from Latvia to Commonwealth of Independent States (CIS) countries has also caused emission fluctuations 1998-2000.

Since 2010 rapid emission growth could be observed in Mineral industry where $CO_2$ emission increase was a result of setting up of new dry process technological plant in cement production. In 2014 the $CO_2$ and $CH_4$ emissions from metal industry have decreased by 100% compared to 1990 due to insolvency of the only metal production plant in Latvia.

Emissions of F-gases have been increasing significantly since 1995. The sharp increase of F-gases emissions is related to growing demand for refrigeration and air conditioning equipment along with improving economic situation in Latvia. There is no manufacturing of F-gases containing products in the country thus emissions mainly depend on consumption of imported products.

**Table 4.1 Greenhouse gas emission trend in 1990–2014 (kt $CO_2$ eq.)**

| Year | Total | 2.A Mineral Industry | 2.C Metal Industry | 2.D Non-Energy Products from Fuels and Solvent | 2.F Product Uses as Substitutes for ODS | 2.G Other Product Manufacture and Use | 2.H. Other |
|---|---|---|---|---|---|---|---|
| **1990** | 707.49 | 589.20 | 52.66 | 64.32 | NO,NA,NE | 1.30 | NA,NO |
| **1991** | 610.71 | 518.03 | 35.76 | 55.62 | NO,NA,NE | 1.30 | NA,NO |
| **1992** | 322.83 | 244.42 | 23.54 | 53.58 | NO,NA,NE | 1.29 | NA,NO |
| **1993** | 169.86 | 84.68 | 28.76 | 55.16 | NO,NA,NE | 1.26 | NA,NO |
| **1994** | 217.84 | 132.13 | 31.20 | 53.27 | NO,NA,NE | 1.24 | NA,NO |
| **1995** | 237.25 | 146.12 | 26.17 | 52.07 | 11.50 | 1.40 | NA,NO |
| **1996** | 249.20 | 158.70 | 24.91 | 51.62 | 12.59 | 1.38 | NA,NO |
| **1997** | 266.26 | 159.33 | 42.61 | 50.02 | 12.73 | 1.56 | NA,NO |
| **1998** | 273.35 | 159.41 | 45.43 | 51.49 | 15.33 | 1.70 | NA,NO |
| **1999** | 307.50 | 193.31 | 44.07 | 51.17 | 17.07 | 1.88 | NA,NO |
| **2000** | 260.31 | 143.39 | 43.64 | 50.77 | 20.46 | 2.05 | NA,NO |
| **2001** | 283.27 | 163.78 | 42.75 | 50.28 | 23.92 | 2.54 | NA,NO |
| **2002** | 298.08 | 174.49 | 42.88 | 49.76 | 27.20 | 3.75 | NA,NO |
| **2003** | 315.17 | 182.33 | 47.16 | 50.61 | 31.18 | 3.88 | NA,NO |
| **2004** | 350.66 | 194.38 | 51.47 | 52.91 | 47.54 | 4.36 | NA,NO |
| **2005** | 347.38 | 183.35 | 36.11 | 54.72 | 63.48 | 4.88 | 4.85 |
| **2006** | 404.92 | 212.85 | 30.92 | 53.18 | 98.09 | 5.16 | 4.73 |
| **2007** | 432.84 | 218.14 | 27.69 | 57.80 | 123.59 | 5.63 | NA,NO |
| **2008** | 447.99 | 214.83 | 24.81 | 60.21 | 142.02 | 6.13 | NA,NO |
| **2009** | 441.11 | 203.94 | 26.88 | 49.30 | 152.14 | 8.85 | NA,NO |
| **2010** | 711.12 | 467.40 | 25.26 | 45.18 | 164.42 | 8.87 | NA,NO |
| **2011** | 823.16 | 567.21 | 15.20 | 46.31 | 184.97 | 9.45 | NA,NO |
| **2012** | 892.51 | 584.98 | 55.98 | 51.75 | 190.21 | 9.59 | NA,NO |
| **2013** | 828.38 | 550.26 | 13.92 | 49.39 | 204.35 | 10.46 | NA,NO |
| **2014** | 837.00 | 568.01 | 0.01 | 46.33 | 212.06 | 10.59 | NA,NO |
| **Share of total % in 2014** | 7.4% | 5.0% | 0.0001% | 0.4% | 1.9% | 0.1% | 0.0% |
| **2014 versus 2013** | +1.0% | 3.2% | -99.9% | -6.2% | 3.8% | 1.3% | 0.0% |
| **2014 versus 1990** | +18.3% | -3.6% | -100.0% | -28.0% | 1743.8%[25] | 713.4% | 0.0% |

Key categories under IPPU sector are listed in Table 4.2. Information regarding approaches used for key category analysis available in Chapter 1.5 and Annex 1.

**Table 4.2 Key categories of IPPU sector in 2016 submission**

| IPCC category/Group | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 2.A.1.Cement Production | $CO_2$ | L1, L2,T1,T2 | X | X |
| 2.A.2. Lime Production | $CO_2$ | T1,T2 | X | X |
| 2.A.4. Other process uses of carbonates | $CO_2$ | T1,T2 | | X |
| 2.C.1 Iron and Steel Production | $CO_2$ | T1 | | X |

[25] *2014 versus 1995*

| IPCC category/Group | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 2.D.3. Solvent Use | $CO_2$ | L1 | | X |
| 2.F.1. Refrigeration and air conditioning | HFCs | L1, L2 | X | X |

## *4.2 MINERAL INDUSTRY (CRF 2.A)*

### 4.2.1 Category description

2.A Mineral industry sector is the major emission source under IPPU sector. Most important sources of non-energy $CO_2$ emissions under 2.A sector is a cement production, limestone use in glass production as well as metal and lime production. Mineral industry sector GHG emissions amounts to 568.01 kt (5.0%) of total anthropogenic GHG emissions in Latvia in 2014.

Emissions from Mineral industry have decreased by 3.6% since 1990 and increased by 3.2% compared to 2013 (Figure 4.3 and Table 4.1).

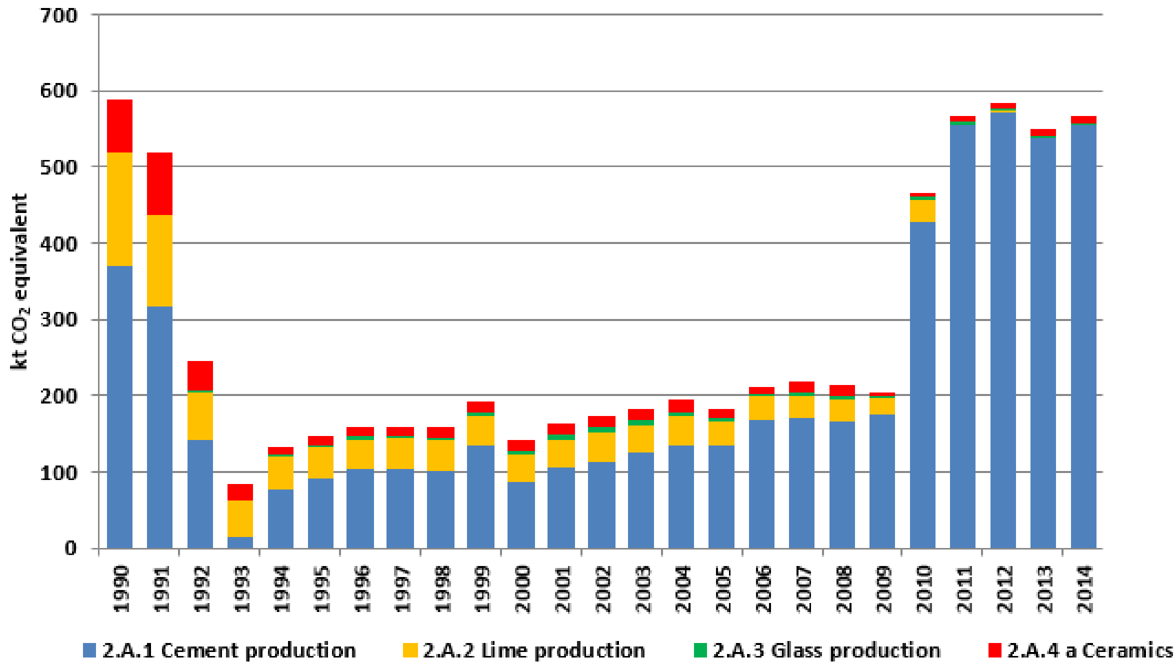


**Figure 4.3 Emissions from Mineral industry in 1990–2014 (kt $CO_2$ eq.)**

$CO_2$ emissions are strongly influenced by economic situation in the country. Emission curve reflects economic crisis in time period 1991–1993 after transition of national economy due to broke down of the former Soviet Union market when significant amount of industrial producers stopped their activity (Table 4.3). Also radical decreases of $CO_2$ emissions from 1998 to 2000 are explainable with markably decreased export from Latvia to Commonwealth of Independent States (CIS).

**Table 4.3 Emissions from 2.A Mineral Industry in 1990–2014 (kt)**

| | $CO_2$ | | | | | NOx | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| | 2.A | 2.A.1 | 2.A.2 | 2.A.3 | 2.A.4.a | | | | |
| **1990** | 589.20 | 370.80 | 148.86 | 0.36 | 69.18 | 0.90 | NO,NA,NE | 0.16 | 3.41 |
| **1995** | 146.12 | 91.07 | 40.66 | 3.40 | 10.98 | 0.24 | NO,NA,NE | 0.04 | 0.90 |

| | $CO_2$ | | | | | NOx | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| | 2.A | 2.A.1 | 2.A.2 | 2.A.3 | 2.A.4.a | | | | |
| **2000** | 143.39 | 86.33 | 36.85 | 5.82 | 14.39 | 0.23 | NO,NA,NE | 0.04 | 0.85 |
| **2005** | 183.35 | 134.46 | 32.22 | 5.71 | 10.96 | 0.36 | NO,NA,NE | 0.07 | 1.35 |
| **2006** | 212.85 | 168.59 | 30.37 | 2.69 | 11.20 | 0.45 | NO,NA,NE | 0.08 | 1.69 |
| **2007** | 218.14 | 170.73 | 30.21 | 4.44 | 12.76 | 0.46 | NO,NA,NE | 0.09 | 1.73 |
| **2008** | 214.83 | 167.48 | 28.42 | 4.03 | 14.90 | 0.45 | NO,NA,NE | 0.09 | 1.71 |
| **2009** | 203.94 | 176.18 | 21.80 | 2.61 | 3.36 | 0.55 | NO,NA,NE | 0.04 | 1.74 |
| **2010** | 467.40 | 428.87 | 28.59 | 4.47 | 5.47 | 0.49 | 0.81 | 0.02 | 0.07 |
| **2011** | 567.21 | 555.14 | 0.27 | 4.33 | 7.48 | 1.02 | 1.73 | 0.03 | 0.38 |
| **2012** | 584.98 | 572.33 | 1.34 | 3.78 | 7.53 | 1.52 | 3.53 | 0.01 | 0.39 |
| **2013** | 550.26 | 537.64 | 0.27 | 3.29 | 9.05 | 1.54 | 2.58 | 0.01 | 0.17 |
| **2014** | 568.01 | 555.78 | 0.46 | 0.94 | 10.83 | 1.80 | 2.23 | 0.02 | 0.15 |
| **Share of IPPU total in 2014, %** | 67.9% | 66.4% | 0.1% | 0.1% | 1.3% | - | - | - | - |
| **2014 versus 2013** | +3.2% | +3.4% | +67.4% | -71.4% | +19.7% | +17.9% | -13.7% | +41.2% | -11.2% |
| **2014 versus 1990** | -3.6% | +49.9% | -99.7% | +165.0% | -84.3% | +95.7% | +176.5%[26] | -88.1% | -95.6% |

Due to Latvia's economic downturn in 2007–2008 the industry development was slowing down as the financing and real estate sectors started to dominate in national economy. In 2009-2010 emissions from 2.A.1 Cement production have been increasing due to cement production plant set up new technology and installations that increased its capacity approximately 2.4 times. In 2013 there are decreased produced amount of clinker by 6.6%. There is increased activity in Mineral industry sector about 3.1% in 2014.

Under 2.A Mineral industry NMVOC emissions from glass fibre production and also $SO_2$, $NO_x$ and NMVOC emissions from cement production are reported. Indirect $CO_2$ emissions were estimated from NMVOC emissions in 2.A.3 sector from glass fibre production. $NO_x$, CO and NMVOC emissions from cement production are reported in 2.A.4.d Other sector due to structure of CRF Reporter software when it is not possible to report $NO_x$, CO and NMVOC emissions in 2.A.1 Cement Production sector and NMVOC emissions from glass fibre production.

Reported emissions, calculation methods and type of emission factors for the 2.A Mineral Industry in the Latvian inventory are summarized in Table 4.4.

**Table 4.4 GHG emission categories, methods and gases reported from 2.A Mineral Industry**

| **Category** | **Method used** | **Gases reported** |
|---|---|---|
| | **2.A Mineral Industry** | |
| 1. Cement Production | Tier2 | $CO_2$, CO, NMVOC, $SO_2$, NOx |
| 2. Lime Production | Tier1, 2, 3 | $CO_2$ |
| 3. Glass Production | Tier1,2 | $CO_2$ |
| Production of Glass (Use of fluorspar) | Tier1 | $CO_2$ |
| Production of Glass (Use of potash) | Tier1 | $CO_2$ |
| Production of Glass (Use of witherite) | Tier1 | $CO_2$ |
| Production of Glass Fibre | Tier1,2 | $CO_2$, NMVOC |

[26] *2014 versus 2010*

| Category | Method used | Gases reported |
|---|---|---|
| 4.Other Process Uses of Carbonates | | |
| 4.a Ceramics | | |
| Production of bricks | Tier2 | $CO_2$ |
| Production of tiles | Tier1,2 | $CO_2$ |

## 4.2.2 Cement Production (CRF 2.A.1)

### 4.2.2.1 Category description

$CO_2$, NOx, CO, NMVOC and $SO_2$ emissions are estimated from Cement production sector.

In 2014 GHG emissions from Cement production amounted 555.78 kt $CO_2$ eq (4.9%) from Latvia`s total $CO_2$ equivalent emissions without LULUCF and 66.4% from total IPPU sector emissions. Compared to 2013 emissions have increased by 3.4%, but compared to 1990 emissions have increased by 49.9% (Table 4.3 and Figure 4.4).

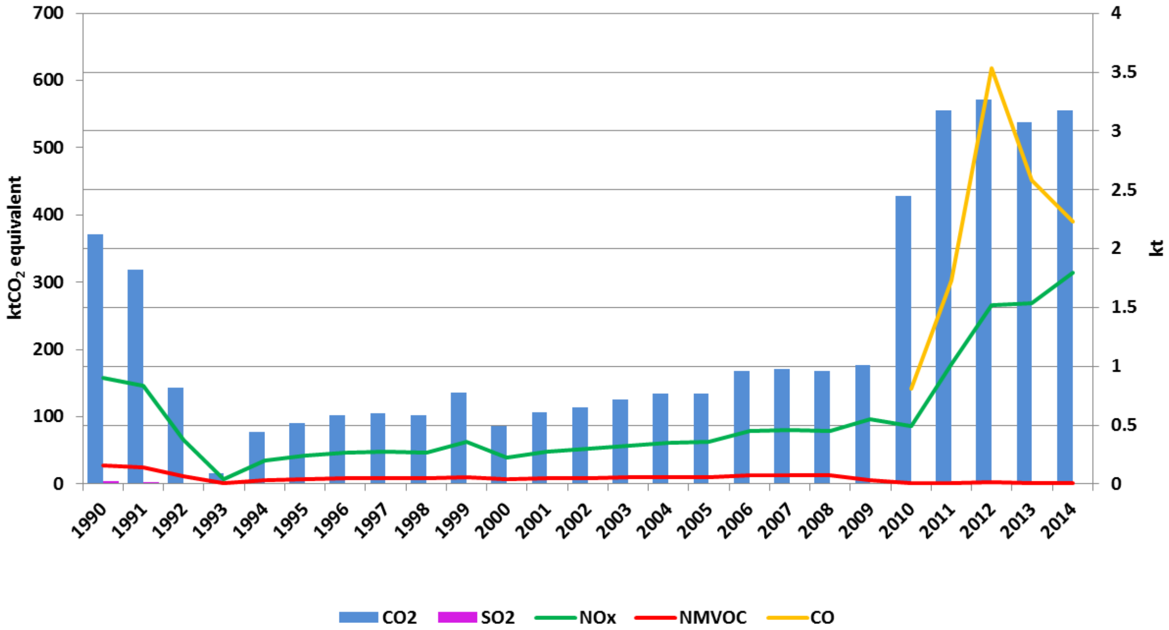


**Figure 4.4 Emissions from Cement production in 1990–2014 (kt $CO_2$ eq.)[27]**

The emission curve represents the total situation in national economy when the big decrease happened in the beginning of the 1990s due to changes in national economy, domestic market and production demand. $CO_2$ emissions from Cement Production had decreased by 95.6% in 1990-1993. Increase of emissions in period 2000-2007 by 97.8% represents the development of construction sector and development of external market. Still in the middle of 2009 new production plant with dry process kiln production technology was built instead of the old one where the wet process kiln technology was used. Consequently the cement kiln dust recovery was stopped and further cement kiln dust was collected and transported to landfill for storage. Therefore amount of cement kiln dust and CKD/clinker ratio increased sharply in 2010-2014 that affected $CO_2$ emissions.

*[27] $SO_2$, NOx and NMVOC on secondary axis*

NMVOC emissions have decreased in 2009-2010 by 72%. That is explained with adjustment of emission factor for new dry production process that is lower than for the old production plant's wet kiln process technology. $SO_2$, NOx and CO emissions are automatically detected at plant site.

Starting from 2010 fully dry process kiln is used in cement production. For 2009 both kiln processes - dry and wet was used in cement production. Previously (1990 – 2009 partly) only wet process kiln was used in cement production. Due to increasing activity for cement clinker production in 2010, decrease of $SO_x$ emissions can be observed. As raw materials tyres and lube oil consisting of sulphur compounds were used. For 2010 $SO_x$, $NO_x$ and CO data are not representative as new technology began with full capacity only in July on 2nd half of year 2010 and fully in 2011. Emissions from 2.A.1 sector increased in 2010 due to capacity building in cement production comparing with previous years. Produced clinker amount are decreased about 6.6% and $CO_2$ emissions about 6.1% in 2013. Production of cement clinker is depending on the demand in internal and external market. In 2014 produced amount of clinker have increased by about 3.6% compared to 2013.

#### 4.2.2.2 Methodological issues

Tier 2 method from 2006 IPCC Guidelines was used to estimate clinker production data from final cement production amount when clinker / cement ratio for different types of cement is known. The same method is used for $CO_2$ emission factor and emission estimation. $CO_2$ emissions from clinker production are estimated using 2006 IPCC Guidelines equation 2.2[28]

$$CO_2\ Emissions = M_{cl} \times EF_{cl} \times CF_{ckd}$$

*where:*
*$CO_2$ Emissions- emissions of $CO_2$ from cement production, tonnes*
*$M_{cl}$ – weight (mass) of clinker produced, tonnes*
*$EF_{cl}$ – emission factor for clinker, tonnes $CO_2$ /tonne clinker. This clinker emission factor ($EF_{cl}$) is not corrected for CKD*
*$CF_{ckd}$ – emissions correction factor for CKD, dimensionless*

Tier 2 approach from EMEP/CORINAIR 2007 was used to calculate NOx, NMVOC, $SO_2$ emissions from cement production taking into account produced amount of clinker in wet and dry process kiln and technology based EFs.

$CO_2$ emission factor is calculated for all years in time series 1990–2014 according to CaO content in used limestone that is measured in laboratory of cement production facility (Table 4.5). LEGMC is able to use all laboratory measurements data from cement production plant as CaO content in limestone is available to estimate $CO_2$ emission factor for clinker. This emission factor corresponds to Tier 2 emission factor estimations from 2006 IPCC Guidelines as $CO_2$ emissions from Cement Production sector.

$CO_2$ emission factor is calculated using equation 2.4 from 2006 IPCC Guidelines[29] taken into account country-specific data on CaO content of clinker and the fraction of CaO that was derived from a carbonate source (generally $CaCO_3$):

$$EF_{clc} = (0.785 \times CaO_{\ content}) \times CKD_{correction}$$

[28] *http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html, Mineral industry emissions, p 2.9*
[29] *http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html , Mineral industry emissions ,p 2.12*

*where:*
*$EF_{clc}$ – clinker production EF (kt/kt)*
*0.785 – molecular weight ration of $CO_2$ to CaO in the raw material ($CaCO_3$)*
*CaO – CaO content (weight fraction) in produced clinker (%)*
*$CKD_{correction}$ – correction factor for cement kiln dust*

CKD correction factor is calculated using equation 2.5 from 2006 IPCC Guidelines:

$$CF_{ckd} = 1 + (M_d/M_{cl}) \times C_d \times F_d \times (EF_c/EF_{cl})$$

*where:*
*$CF_{ckd}$- emissions correction factor for CKD, dimensionless*
*$M_d$- weight of CKD not recycled to the kiln, tonnes*
*$M_{cl}$- weight of clinker produced, tonnes*
*$C_d$- fraction of original carbonate in the CKD (i.e., before calcination), fraction*
*$F_d$ – fraction calcination of the original carbonate in the CKD, fraction*
*$EF_c$ – emission factor for the carbonate (2006 IPCC Guidelines Chapter 2 Table 2.1), tonnes $CO_2$ /tonne carbonate*
*$EF_{cl}$ -emission factor for clinker uncorrected for CKD ( i.e., 0.51 tonnes $CO_2$/ tonne clinker), tonnes $CO_2$/ tonne clinker*

**Table 4.5 Average CaO content in clinker (%) and average $CO_2$ emission factor in 1990–2014 (t $CO_2$ / t clinker)**

| | Average CaO content (%) | $CO_2$ EF without CKD factor | CKD correction factor | $CO_2$ EF with CKD factor |
|---|---|---|---|---|
| **1990** | 64.60 | 0.507 | 1.094 | 0.555 |
| **1995** | 64.06 | 0.503 | 1.031 | 0.518 |
| **2000** | 64.41 | 0.506 | 1.021 | 0.516 |
| **2005** | 64.41 | 0.506 | 1.002 | 0.507 |
| **2006** | 64.75 | 0.508 | 1.003 | 0.510 |
| **2007** | 64.06 | 0.503 | 1.004 | 0.505 |
| **2008** | 63.72 | 0.500 | 1.001 | 0.501 |
| **2009** | 65.27 | 0.512 | 1.008 | 0.517 |
| **2010** | 65.24 | 0.512 | 1.003 | 0.514 |
| **2011** | 64.34 | 0.505 | 1.004 | 0.507 |
| **2012** | 64.30 | 0.505 | 1.004 | 0.507 |
| **2013** | 64.65 | 0.508 | 1.004 | 0.510 |
| **2014** | 64.50 | 0.506 | 1.004 | 0.509 |

For 1996–2005 average CaO content data (64.41%) of 1995 and 2006 was used in emission calculation since data for average CaO content in produced clinker for years 1996–2005 was not available in cement production plant. Afterwards data of average CaO content were available from plant laboratory and reported to LEGMC for $CO_2$ emission factor calculation.

*Indirect GHG emission factors*

As the EFs for $NO_x$, NMVOC and $SO_2$ are not available in EMEP/EEA 2013[30] (marked as "Not Estimated") the EFs from EMEP/CORINAIR 2007[31] were used as these emissions are emitted in the production according to cement production plant. Till 2010 the EFs were divided for dry and wet process kiln.

$NO_x$, CO and $SO_2$ emissions as plant-specific data that are detected automatically from dry process production plant are reported since 2010. To estimate NOx, CO, SOx emissions from cement production (2A1 sector under IPPU), national database "2-Air" is used. "Cemex", the only cement production plant, has indicated in its "2-Air" report that these emissions arise from technological processes which include also heat generation to maintain certain temperatures during particular process. Until 2010 indirect GHG emissions under 2A1 sector were calculated using EMEP/CORINAIR 2007 and EMEP/EEA 2009 methodology, but afterwards these emissions were automatically detected at plant site, and measurements are taken in the main chimney. However, as these values are measured directly in the chimney, there is no way to allocate emissions under Energy and IPPU sectors separately (there are both emissions from fuel combustion and technological processes). Regarding calculation of indirect GHGs, to avoid double counting, the following fuel types (used tyres, ecofuel, coal, natural gas consumed in "Cemex") are subtracted from Energy part and their emissions can be considered as included elsewhere "IE" (2A1 sector under IPPU) in case of cement producer "Cemex". As for GHGs, these emissions are taken from EU ETS reports ($CO_2$) or calculated ($CH_4$, $N_2O$), therefore can be allocated under appropriate sectors. Evaporation from raw materials depends on composition of this material. Mainly it is raw material containing sulphates and sulphides that evaporates in very small amount before to the production process. Mainly SOx reaction happens in middle of process in high temperatures. At the end of the process all necessary SOx amount is fixed in clinker contain and residual SOx are detected in chimney and emitted to the air. For both technologies only NMVOC emissions are estimated using EFs provided in EMEP/CORINAIR 2007 (Table 4.6).

**Table 4.6 EFs for cement clinker production emission estimation (kt/kt)**

| | NOx | NMVOC | $SO_2$ |
|---|---|---|---|
| wet process kiln | 0.00135 | 0.00023 | 0.0051 |
| dry process kiln | 0.00175 | 0.00001 | 0.0051 |

*Activity data*

The produced clinker is not weighted in cement production plant but estimated from final produced amount of cement clinker. As plant produce many types of cement, clinker activity data are estimated taking into account different cement types multiplying with cement/clinker ratio and also mass balance of cement, clinker and used additives in cement production. Cement production activity data from plant is available according to annual EU ETS GHG report by plant. As data of produced clinker is not available (plant has non-stop production process) the alternative is to take total amount of cement clinker data and estimate clinker amount back to clinker production data. In the cement production plant it is done for the EU ETS annual reporting by taking into account clinker and cement ratio for the

[30] *http://www.eea.europa.eu/publications/emep-eea-guidebook-2013 , Mineral products (pages 12-13)*
[31] *http://www.eea.europa.eu//publications/EMEPCORINAIR5 , Group 4: Production processes, B3311pdf. (pages 12-13)*

particular types of produced cement. Activity data of cement and clinker is plant- specific data reported by cement clinker producer. Final clinker data are calculated using plant mass balance approach in two steps:

1) Clinker production = ((cement export – cement stock changes) * clinker/cement ratio)) - clinker export – clinker stock changes ;
2) Produced clinker = used clinker + clinker export – clinker import + clinker stock change.

Approach (1) is used for each produced cement type to calculate produced clinker amount that is produced in respective plant.

CaO content is measured in the cement production companies and $CO_2$ EF for produced clinker is estimated according to equation 2.4 from 2006 IPCC Guidelines[32]. As it is stated by cement producer and verified by ISO accredited verifiers the cement kiln dust is weighted at the plant before the transportation outside the company for the storage.

In 2010 amount of clinker is produced almost 2.4 times more as in previous year. It is explained with new dry process kiln technology and increasing capacity of clinker production plant. Full capacity of dry process cement clinker production has caused the $CO_2$ emission increase starting from 2010. Cement clinker are produced for internal use but mainly for export.

**Table 4.7 CKD correction factor in 1990–2014**

| | Produced clinker (kt) | Produced cement kiln dust (kt) | CKD / clinker ratio (%) | Corrected CKD / clinker ratio (%) |
|---|---|---|---|---|
| **1990** | 668.50 | 175.49 | 26.25 | 0.094 |
| **1995** | 175.69 | 15.00 | 8.54 | 0.031 |
| **2000** | 167.18 | 10.00 | 5.98 | 0.021 |
| **2005** | 265.40 | 1.53 | 0.58 | 0.002 |
| **2006** | 330.65 | 2.89 | 0.87 | 0.003 |
| **2007** | 338.31 | 3.35 | 0.99 | 0.004 |
| **2008** | 334.46 | 0.99 | 0.30 | 0.001 |
| **2009** | 340.99 | 8.08 | 2.37 | 0.008 |
| **2010** | 834.94 | 7.02 | 0.84 | 0.003 |
| **2011** | 1095.23 | 10.87 | 0.99 | 0.004 |
| **2012** | 1129.11 | 13.29 | 1.18 | 0.004 |
| **2013** | 1054.95 | 12.43 | 1.18 | 0.004 |
| **2014** | 1093.04 | 12.92 | 1.18 | 0.004 |

As it can be seen in (Table 4.7) the plant specific data resulted in a higher CKD ratio (26.25%) in 1990, while the CKD in 2008 is much lower (0.30%). Still to ensure comparability, as required by the IPCC GPG 2000 and also reflect the national circumstances, Latvia uses the

[32] *http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html , Mineral industry emissions ,p 2.12*

maximum permissible good practice guidance limit of CKD – 6-8% where the plant specific data exceeds 8% for the calculation of $CO_2$ emissions from cement production. CKD ratio was changed to 8% that is maximum permissible good practice guidance limit of CKD (6%–8%) although official statistical data resulted in different CKD ratio and it changed year to year depending on produced amount of clinker and cement kiln dust. In latest years there are quite stable situation in clinker production and CKD ratio is aproximately 1.18%.

According to cement production plant the CKD amount is weighted before it is sent to disposal site. The amount of weighted CKD as well as procedures of all data obtaining is verified by the accredited verifier within EU ETS. According to Verification Company all production facilities as well as data obtaining and storage was inspected at the production company personally by the lead verificator. All verification reports also are publicly available till 2012 through LEGMC web page http://www.meteo.lv/lapas/uznemumi-kuriem-izsniegtas-siltumnicefekta-gazu-emisijas-atlaujas-2-pe?id=1253&nid=575, after responsible for such information publication is State Environmental Service of Latvia - http://www.vvd.gov.lv/izsniegtas-atlaujas-un-licences/seg-atlaujas/, internal verification documentation is confidential. The cement clinker is produced only from limestone and CKD amount changes due to production technology. For the years 2005-2008 CKD has decreased due to improvement of used technology.

#### 4.2.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of cement production data is assumed as 10% as clinker production data is estimated from final cement production data because produced clinker is not weighted separately before the final cement mixture is produced.

$CO_2$ emission factor for 2.A.1 sector is estimated based on plant specific data of used limestone characterizations so average uncertainty of 5% is assumed.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years. GHG emissions from the sector are estimated or reported as not occurring / not applicable therefore there are no "not estimated" sectors.

All industrial production data used in emission estimation from 2.A Mineral Products sector is taken from the annual GHG reports that industrial producers submit within EU ETS. According to EU ETS legislation all GHG reports have to be verified by the ISO accredited verifiers that checks that all reported information – activity data, $CO_2$ emission factors, estimated emissions as well as estimation methodology, is correct and corresponds to certain requirements from the legislation. Cement and lime production facilities certify that all additional information for $CO_2$ emission estimation is verified. Regional Environmental Board also checks the annual GHG reports and compares the data in the reports with the data reported by the enterprise to database "2-AIR" and to CSB.

Time series consistency was checked by verifying IEF, AD and emission changes and attention was paid to important changes that increase/decrease and are explained in NIR.

#### 4.2.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

QA/QC check is performed with Tier 2 method from 2006 IPCC Guidelines.

Emissions are checked using time series consistency check for the IEF estimated in CRF Reporter and all IEF changes - in time series are double-checked and reasonable explanation for IEF changes has to be found under each subsector source category description.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in national legislation. All findings were documented and introduced in GHG inventory. All corrections are archived.

Checks performed pursuant to Article 7(1)(l) of Regulation (EU) No 525/2013 are done to compare EU ETS data with GHG inventory emissions. These checks results with differences represented in Table 4.8.

**Table 4.8 Differences between $CO_2$ emissions under ETS and inventory data of cement production for 2013 and 2014**

| 2.A.1 Cement Production | | | Difference |
|---|---|---|---|
| Year | IPCC methodology 2006 IPCC Guidelines Volume 3 Chapter 2 equation 2.2 | Monitoring and reporting Regulation[33] Art.30 and 31. | |
| 2013 | 537.64 kt | 560.37 kt | 4.22%, |
| 2014 | 555.77 kt | 580.63 kt | 4.47% |

Differences between $CO_2$ emissions under European Union Emission Trading system (EU ETS) and GHG inventory are caused by use of different emission calculation methodologies from cement production under UNFCCC reporting (IPCC GPG 2000 and 2006 IPCC Guidelines) and EU ETS reporting[34]. There is only one cement plant in Latvia which uses Tier 1 method in ETS reporting (according to EU Monitoring and reporting Regulation). Default EFs are taken for $CO_2$ emission calculation as it is not possible to obtain all necessary laboratory measurements in plant laboratory to apply higher Tier method as this laboratory is not accredited.

#### 4.2.2.5 Category-specific recalculations

No specific recalculations were done in this sector.

#### 4.2.2.6 Category-specific planned improvements

No improvements are planned for this sector.

[33] *http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0601&from=EN*

[34] *Under EU ETS up to 2012 the calculation methodologies from EU ETS directive 2003/87/EC and Monitoring and Reporting guidelines were used but starting the EU ETS Phase 3 in 2012 the Monitoring and reporting Regulation is used for the emission calculation.*

### 4.2.3 Lime Production (CRF 2.A.2)

#### 4.2.3.1 Category description

Under this sector $CO_2$ emissions from lime production in Iron & Steel production are reported as these emissions are estimated based on total produced quicklime (CaO) data and limestone and dolomite use in one lime production plant.

Lime production sector $CO_2$ emissions amounts to 0.46 kt (0.1%) of total IPPU emissions in Latvia in 2014.

$CO_2$ emissions from 2.A.2 sector are decreased about 99.7% since 1990 and increased by about 67.4% compared to 2013 (Figure 4.5 and Table 4.9).

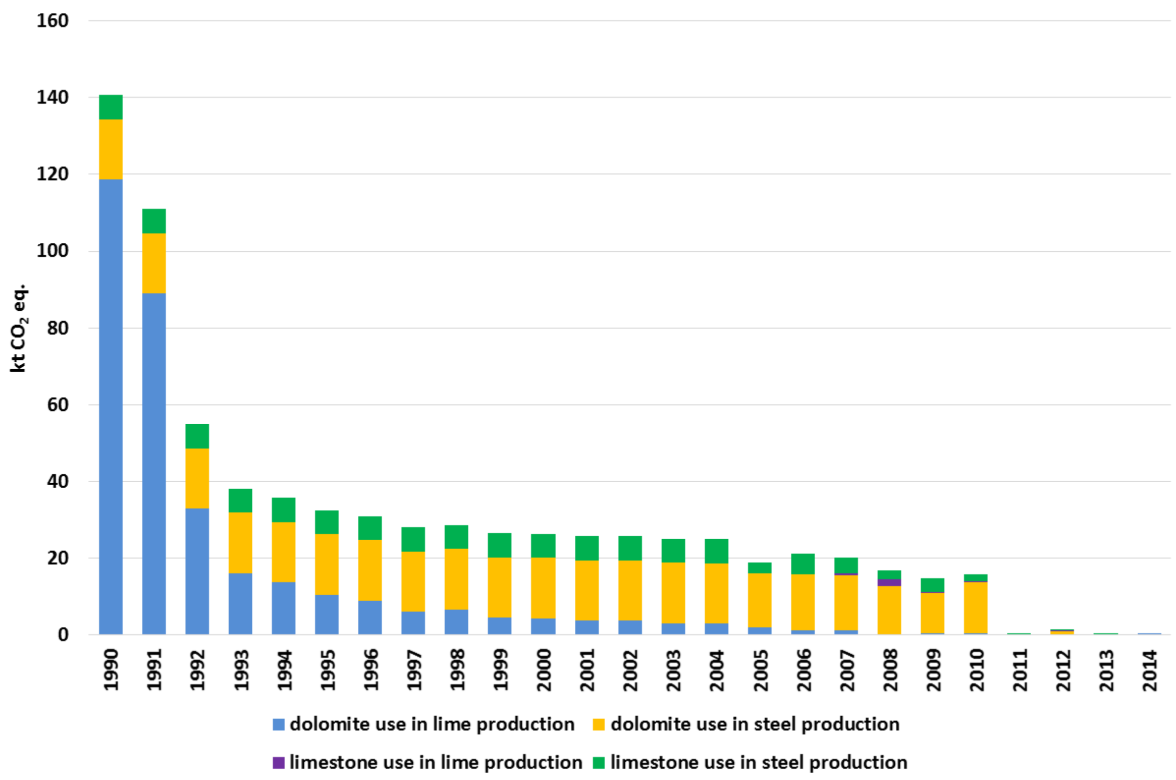


**Figure 4.5 $CO_2$ emission from limestone and dolomite use in lime and steel production in 1990–2014 (kt)[35]**

As it can be seen in Figure 4.5 the $CO_2$ emissions from dolomite use in lime production plant as well as dolomite and limestone use in steel production are continuously decreasing since the beginning of 1990s due to recession of overall national economy. In 2013-2014 dolomite in steel production and limestone in lime production are not used anymore. As raw materials very small amount of limestone in steel production is used. Dolomite are still used in lime production.

In iron & steel production facility lime is necessary for steel smelting in open hearth furnaces. Quicklime  is produced only from limestone in vertical shaft kiln. The plant reports

[35] *dolomite use (steel production), limestone use (steel production), dolomite use (lime production), on secondary axis*

their non-marketed quicklime production data for 2005-2013 within EU ETS so the estimated emissions as well as used activity data and emission factors are taken from plant's annual GHG report (Table 4.9).

**Table 4.9 $CO_2$ emissions from lime production in 1990–2014 (kt)**

| | In steel production | In lime production |
|---|---|---|
| **1990** | 30.238 | 118.620 |
| **1995** | 30.238 | 10.422 |
| **2000** | 32.565 | 4.283 |
| **2005** | 30.374 | 1.849 |
| **2006** | 29.065 | 1.306 |
| **2007** | 28.628 | 1.582 |
| **2008** | 26.537 | 1.887 |
| **2009** | 21.357 | 0.438 |
| **2010** | 28.050 | 0.542 |
| **2011** | 0.118 | 0.154 |
| **2012** | 0.980 | 0.356 |
| **2013** | 0.000 | 0.275 |
| **2014** | NO | 0.460 |

In 2008-2009 emissions have decreased significantly due to the economic crisis. In 2010 emissions from lime production are increased by about 23.8% due to overall increase of activity in IPPU. In 2011 emissions of produced lime that are used for metal production are decreased by 99.6% due to changes in metal production technology as plant switched on steel production in Electric arc furnace (EAF). Operation of this plant was partially suspended due to reconstruction. Previously open hearth furnace (OHF) technology was used for steel making.

In latest years $CO_2$ emissions from 2.A.2 have decreased due to steel production plant`s reconstruction and insolvency which was the reason why plant was not operating full time anymore.

#### 4.2.3.2 Methodological issues

*Methods*

$CO_2$ emissions from lime production in steel production plant are estimated using Tier 1 method based on total produced quicklime data and default emission factor.

$$EM = EF \times AD$$

*where:*
*EM – $CO_2$ emissions from quicklime production (kt)*
*EF – default EF according to IPCC GPG 2000 ($tCO_2$/t lime)*
*AD – quicklime production data (kt)*

$CO_2$ emissions from Lime production in two direct lime production plants are calculated on the basis on data of carbonates – dolomite and limestone use. Purity factor from IPCC GPG 2000 is taken into account in estimation of $CO_2$ emissions from dolomite use in lime production. $CO_2$ emissions from limestone use in lime production processes are estimated with Tier 2 method based on plant specific activity data and default IPCC 1996 emission factors. Tier 3 method is used in $CO_2$ emission estimation from dolomite use in lime production processes as plant specific activity data as well as plant specific $CO_2$ emission factors are available.

*Emission factors*

Default $CO_2$ emission factor from IPCC GPG 2000 was used by steel production plant as per tonne of high calcium quicklime – 0.785 $tCO_2$/t lime[36]. Lime in the particular plant is produced from limestone and dolomite.

Emission factors of limestone and dolomite use in steel production are default ones taken from IPCC 1996 (Table 4.10).

**Table 4.10 $CO_2$ emission factors for limestone and dolomite use (t $CO_2$/t raw material)**

| | **1990–2014** |
|---|---|
| **Limestone use in steel and lime production** | 0.440 |
| **Dolomite use in steel production** | 0.477 |

<u>Plant specific $CO_2$ emission factor for dolomite use in lime production</u>

The used $CO_2$ emission factor of dolomite use in Lime production is considered as plant specific as CaO and CaO*MgO content is taken into account.

According to laboratory measurements made in the only lime production plant in Latvia average content of dolomite is:

$CaCO_3$ – 51.83%;

$MgCO_3$ – 40.80%;

$SiO_2$; $Fe_2O_3$; $Al_2O_3$ – 5.88%;

Others – 1.49%.

According to laboratory data:

- average content of water in dolomite is 5.24%;
- average content of water in produced lime is 0%;
- average content of $CO_2$ in lime is 16.99%;
- average content of dolomite (dry) is 94.76% or 947.6 kg dolomite.

947.6 kg dolomite contains:

491.14 kg $CaCO_3$ (51.86%)

386.62 kg $MgCO_3$ (40.80%)

55.72 kg $SiO_2$; $Fe_2O_3$; $Al_2O_3$ (5.88%)

14.12 kg Others (1.49%)

947.6 kg dolomite complete decomposes and pullulates:

[36] http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html (page 2.22)

491.14 kg $CaCO_3$ × 0.440 (emission factor) = 216.10 kg $CO_2$

386.62 kg $MgCO_3$ × 0.522 (emission factor) = 201.82 kg $CO_2$.

Oxides capture:

491.14 kg $CaCO_3$ × 0.560 (emission factor) = 275.04 kg CaO

(or 491.14 kg $CaCO_3$ – 216.10 kg $CO_2$ = 275.04 kg CaO)

386.62 kg $MgCO_3$ × 0.478 (emission factor) = 184.80 kg MgO

(or 386.62 kg $MgCO_3$ – 201.82 kg $CO_2$ = 184.80 kg MgO)

216.10 kg $CO_2$ + 201.82 kg $CO_2$ + 275.04 kg CaO + 184.80 kg MgO = 877.76 kg

947.6 kg – 877.76 kg = 69.84 kg ballast

Lime is made (theoretical):

275.04 kg CaO + 184.80 kg MgO + 69.84 kg ballast = 529.69 kg lime

$CO_2$ content in lime is 16.99% (practical):

529.69 kg lime – 83.01%

Lime is made (practical):

638.09 kg lime + $CO_2$ – 100%

$CO_2$ content in lime is:

638.09 kg lime + $CO_2$ – 529.69 kg lime = 108.41 kg $CO_2$

$CO_2$ emissions (1 tonne complete decomposition) pullulate:

216.10 kg $CO_2$ + 201.82 kg $CO_2$ – 108.41 kg MgO = 309.51 kg $CO_2$

0.3095 t $CO_2$ proceed from practical decomposition of 1 tonne of dolomite.

Average content of water (5.24%) in used dolomite is taken into account when $CO_2$ emission factor is estimated:

$CO_2$ EF dolomite use in lime production = 309.51 kg $CO_2$ × 94.76% = 0.29329167 t $CO_2$ / t dolomite.

*Activity data*

In this sector activity data from two facilities of lime production and one plant of steel production are collected.

Activity data were taken from industrial production plants. Industrial producers are participants of the EU ETS and the GHG reports of these enterprises have to be freely available according to EU ETS regulations. The GHG reports of EU ETS operators are published on LEGMC home page (http://www.meteo.lv/lapas/uznemumi-kuriem-izsniegtas-siltumnicefekta-gazu-emisijas-atlaujas-2-pe?id=1253&nid=575) (Table 4.11).

**Table 4.11 Amount of produced lime in 1990–2014 (kt)**

| | In steel production | In lime production |
|---|---|---|
| **1990** | 10.452 | 214.225 |
| **1995** | 10.452 | 19.208 |
| **2000** | 13.416 | 7.894 |
| **2005** | 17.097 | 20.435 |
| **2006** | 11.758 | 14.116 |
| **2007** | 12.939 | 15.510 |
| **2008** | 14.842 | 17.283 |
| **2009** | 8.851 | 9.581 |
| **2010** | 16.325 | 17.211 |
| **2011** | NO | 0.185 |
| **2012** | NO | 0.558 |
| **2013** | NO | 0.496 |
| **2014** | NO | 0.831 |

For 1995-2004 the iron production plant reported their activity data additionally based on the information request. Due to the lack of official data it was decided to use year's 1995 activity data for emission estimation for 1990-1995.

Changes of national economy and whole data exchange system in early 1990s were the reason why many data is lost even in production plants. Still to improve $CO_2$ emission estimation in all time series the activity data of first year's data available was used to estimate emissions for the prior years, for example, for Iron & Steel production plant year 2005 data was used to estimate the emissions for 1990-2004. In year 2005 Iron and steel production plant became as ETS participant and detailed activity data is available.

Activity data fluctuates in whole time series. Largest decrease could be observed at the beginning of 1990s when enonomic situation in the county was unstable due to change from a centrally planned economy to a market economy.

In 2010 activity data are raised by 84.4% due to overall increasing of activity in all industrial sectors. Exception is limestone use in steel production. There is no activity of produced quick-lime in Iron & Steel production process due to changes of steel production technological changes. In 2011 the overall decrease of total emissions from lime production by 74.1% could be observed due to changes in steel production technology and fact that operation of this plant was partially suspended due to reconstruction. In latest years there are overall decrease of activity in sector 2.A.2 (Table 4.12). Mainly that could be explained with technological changes in steel production plant as limestone and dolomite is not used anymore.

**Table 4.12 Limestone and dolomite use activity data in lime production (t $CO_2$/t raw material)**

| | Dolomite use (steel production) | Limestone use (steel production) | Dolomite use (lime production) | Limestone use (lime production) |
|---|---|---|---|---|
| **1990** | 33.000 | 14.300 | 404.442 | NO |
| **1995** | 33.000 | 14.300 | 35.535 | NO |
| **2000** | 33.000 | 14.300 | 14.604 | NO |
| **2005** | 29.707 | 6.326 | 6.303 | NO |
| **2006** | 30.491 | 12.025 | 4.452 | NO |
| **2007** | 30.405 | 9.017 | 3.776 | 1.078 |
| **2008** | 26.245 | 5.378 | 0.954 | 3.654 |
| **2009** | 22.393 | 8.472 | 1.149 | 0.229 |
| **2010** | 28.115 | 4.147 | 1.323 | 0.349 |
| **2011** | 0.246 | 0.002 | NO | 0.350 |
| **2012** | 1.555 | 0.541 | 0.730 | 0.323 |
| **2013** | NO | 0.000 | 0.936 | NO |
| **2014** | NO | NO | 1.568 | NO |

#### 4.2.3.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Although according to IPCC GPG 2000 the uncertainty of non-marketed lime production data could reach 100% and more[37] it is assumed that the uncertainty of activity data for non-marketed lime production data in 2.A.2 sector is 2% as only one plant specific data verified by accredited verifier and approved by Regional Environmental Board is used.

As default emission factors for lime production from IPCC GPG 2000 as well as Monitoring Reporting Regulation are used and the uncertainty is assumed 50% due to unavailability of the plant specific data of produced lime and due to the fact that this is default emission factor for quicklime production.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All other GHG emissions except $CO_2$ emission are not relevant and could not be reported in CRF.

Time series consistency was checked by verifying IEF, AD and emission changes and attention was paid to important increase/decrease that are explained in NIR.

#### 4.2.3.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed

[37] *http://www.ipcc-nggip.iges.or.jp/public/gp/english/3_Industry.pdf (page 3.23)*

according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

QA/QC check is performed with Tier 1 method from IPCC GPG 2000.

Activity data, $CO_2$ emission factor and estimated emissions are taken from the annual GHG reports that steel production plant submit within EU ETS.

According to EU ETS legislation all GHG reports have to be verified by the ISO accredited verifiers that checks that all reported information is correct and corresponds to certain requirements from the legislation. Steel production facility certifies that all additional information for $CO_2$ emission estimation is verified. Regional Environmental Boards also checks the annual GHG reports and approves the report if everything reported is correct.

Emissions are checked using time series consistency check for the IEF estimated in CRF Reported and all IEF changes in time series are double-checked and reasonable explanation for IEF changes has to be found under each subsector source category description.

The QC form has been filled in for each category taking into account criteria given in QA/QC plan approved in national legislation. Form then is archived.

Checks performed pursuant to Article 7(1)(l) of Regulation (EU) No 525/2013 are done to comparing EU ETS data with GHG inventory emissions. There were no differences in this sector for 2013 and 2014. Such consistency checks are done in all IPPU sectors.

#### 4.2.3.5 Category-specific recalculations

Recalculations were made for 2011 and 2012 due to the input mistake (there were no activity in lime production facility in 2012 due to reconstruction regarding introduction of best available technologies (BAT)). The same activity data mistakenly was taken into account for 2011 and 2012.

#### 4.2.3.6 Category-specific planned improvements

No improvements are planned for the sector.

### 4.2.4 Glass production (CRF 2.A.3)

#### 4.2.4.1 Category description

Glass production sector GHG emissions amounts to 0.94 kt which constitute 0.1% of total IPPU emissions in Latvia in 2014.

$CO_2$ emissions from 2.A.3 sector have been increasing by 165% since 1990 and decreased by 71.4% comparing with 2013 (Figure 4.6 and Table 4.12).

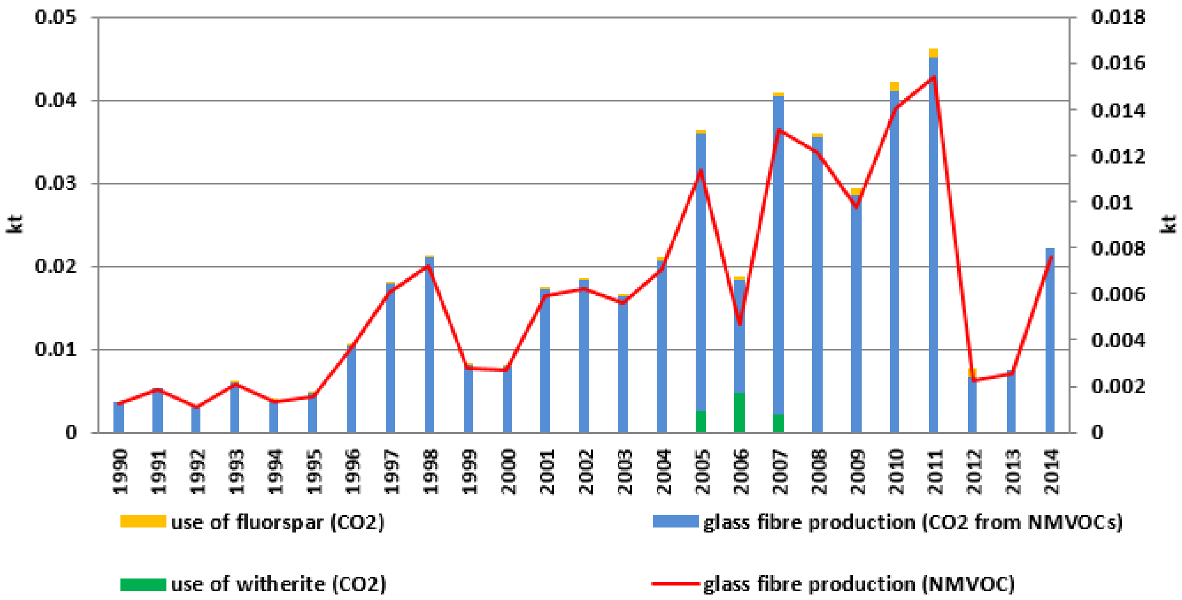


**Figure 4.6 Emissions from raw materials used in glass production 1990-2014 (kt)**[38]

Under 2.A.3 $CO_2$ emissions from use of additional raw materials used in glass production plants – fluorspar, potash and witherite (barium carbonate) are reported, as well as NMVOC emissions from glass production and glass fibre production reported by production facilities. $CO_2$ emissions from glass fibre production processes are estimated from NMVOC emissions due to lack of $CO_2$ emission factors and activity data to $CO_2$ emissions directly.

Use of potash as well as NMVOC emissions from glass production stopped in 2005 when the glass production plant stopped its activity although the use of raw materials in last years of glass production plant increased sharply. Use of witherite is occurring only in 2005-2007 in glass production manufacturing plant but in 2008 and 2009 the plant has suspended it activity. Since 2005 NMVOC emissions are still emitted but in smaller amounts from glass fibre production (Figure 4.6).

NMVOC emissions for time period 1997-2014 were taken from national database "2-AIR" where glass fiber production plant reported its emissions divided by NMVOC sub-type (Table 4.13). For time period 1990-1996 only butylacetate data is available from glass fiber production company's application for GHG permit within EU ETS. For year 2005, also glass production company had reported NMVOC emissions (these emissions are reported under 2.A.4.d sector in CRF Reporter) but since then glass production is not operating therefore NMVOC emissions from glass production are reported only for 2005.

[38] *Emissions from glass fiber production on secondary axis*

**Table 4.13 NMVOC emissions from glass fibre and glass production in 1990–2014 (kt)**

| | Acetone | Butylacetate | Acetic acid | Formaldehyde | Isopropanol (isopropyl) | Methanol (methyl alcohol) | Kerosene | Propan (propyl alcohol) | Propylene glycol methyl ether | Formic acid | **total NMVOC in glass fibre production** | **total NMVOC in glass production** | **total NMVOC (kt)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1990** | NO | 0.001 | NO | NO | NO | NO | NO | NO | NO | NO | **0.00128** | NO | **0.00128** |
| **1995** | NO | 0.002 | NO | NO | NO | NO | NO | NO | NO | NO | **0.00158** | NO | **0.00158** |
| **2000** | 0.140 | 0.664 | 0.294 | 0.066 | NO | NO | 1.570 | NO | NO | NO | **0.00273** | NO | **0.00273** |
| **2005** | NO | 1.493 | 0.909 | 0.107 | 0.276 | 0.084 | 0.659 | 1.200 | NO | 0.233 | **0.00496** | **0.00642** | **0.01138** |
| **2006** | NO | 1.486 | 0.960 | 0.101 | 0.360 | 0.232 | 0.094 | 1.274 | NO | 0.188 | **0.00469** | NO | **0.00469** |
| **2007** | NO | 1.315 | 1.704 | NO | 1.722 | 2.414 | NO | 5.920 | NO | NO | **0.01307** | NO | **0.01307** |
| **2008** | NO | 0.968 | 1.548 | NO | 1.599 | 2.173 | NO | 5.810 | NO | NO | **0.01210** | NO | **0.01210** |
| **2009** | NO | 1.172 | 0.402 | NO | 1.071 | 0.401 | NO | 6.715 | NO | NO | **0.00976** | NO | **0.00976** |
| **2010** | NO | 1.684 | 1.673 | NO | 1.355 | 2.613 | NO | 6.712 | NO | NO | **0.01404** | NO | **0.01404** |
| **2011** | NO | 1.622 | 1.908 | NO | 2.351 | 2.873 | NO | 6.640 | NO | NO | **0.01539** | NO | **0.01539** |
| **2012** | NO | 1.908 | NO | NO | 2.873 | NO | NO | NO | NO | NO | **0.00478** | NO | **0.00478** |
| **2013** | NO | 0.205 | 0.935 | NO | NO | NO | NO | 1.429 | NO | NO | **0.00257** | NO | **0.00257** |
| **2014** | NO | 0.293 | 0.143 | NO | NO | NO | NO | 1.988 | 5.167 | NO | **0.00759** | NO | **0.00759** |

The sharp decrease of limestone use in glass production plant in 1997 and accordingly decrease in $CO_2$ emissions is explained with changes in plant's production technology and overall changes in structure as since 1997 the plant is Joint Stock Company.

The economic crisis is obviously reflecting in $CO_2$ emissions from limestone, dolomite and soda ash use in mineral production (Table 4.14). Also the increase of taxes influenced the ability of industrial producers to invest in future development. In 2010 $CO_2$ emissions from limestone increased by 72% comparing with previous year due to increasing activity in all industrial sectors. In latest years emissions of limestone use in glass production have decreased. In 2012 acetic acid, methanol and propane were not used in production. In 2013 emissions from NMVOC used in glass fibre production increased by 100.7% compared to 1990 when only butylacetate was used as raw material. In 2014 NMVOC emissions increased by 195% due to fact that there are additionally used 5.167 kt propylene glycol methyl ether never used before that cause 0.00759 kt NMVOC emissions from used propylene glycol methyl ether, butyl acetate, acetic acid and propane (propyl alcohol) together. In years 2012-2014 $CO_2$ emissions have been increasing because the new high SiO content technological installation was set up that helps to dectect used amount of soda ash used in production process.

**Table 4.14 $CO_2$ emissions from limestone, dolomite and soda ash use in glass fibre and glass production in 1990–2014 (kt)**

| | **From limestone use** | **From Dolomite use** | **From soda ash use** |
|---|---|---|---|
| **1990** | 0.352 | NO | NO |
| **1995** | 1.947 | 0.809 | 0.643 |

| | From limestone use | From Dolomite use | From soda ash use |
|---|---|---|---|
| **2000** | 2.698 | 1.372 | 1.743 |
| **2005** | 3.111 | 0.996 | 1.554 |
| **2006** | 2.196 | NO | 0.466 |
| **2007** | 4.355 | NO | 0.037 |
| **2008** | 3.992 | NO | NO |
| **2009** | 2.575 | NO | NO |
| **2010** | 4.432 | NO | NO |
| **2011** | 4.279 | NO | NO |
| **2012** | 3.729 | NO | 0.039 |
| **2013** | 2.977 | NO | 0.309 |
| **2014** | 0.554 | NO | 0.366 |

#### 4.2.4.2 Methodological issues

Default methodology from 2006 IPCC Guidelines was used to estimate emissions from Glass production. $CO_2$ emission factors used to estimate emissions from use of raw materials in glass production are plant specific and taken from plants annual GHG reports within EU ETS (Table 4.11). NMVOC emissions for time period 1997-2014 are taken from national database "2-AIR" where both glass production and glass fibre production companies report their emissions. NMVOC emissions for 1990-1996 are estimated only for butylacetate use that glass fibre production company reported in its application for GHG permit during the implementation of ETS in Latvia.

$CO_2$ emissions from limestone and dolomite use and soda ash use in glass production are estimated using Tier 2 method based on plant- specific activity data and default IPCC 1996 emission factors.

Indirect $CO_2$ emissions from glass fibre production processes were estimated according to 2006 IPCC Guidelines. An explanation of indirect $CO_2$ emission estimation based on carbon conversion factor and average default carbon content amount is provided. $CO_2$ emission factor is not provided in methodology and it is not possible to obtain activity data for direct $CO_2$ emission estimation.

NMVOC emissions were taken as activity data for $CO_2$ calculation and $CO_2$ emissions were estimated using carbon conversion factor.

$$E_{CO_2} = EF_{CO_2} \times NMVOC$$

*where:*
*$E_{CO2}$ – $CO_2$ emissions (kt)*
*$EF_{CO2}$ – estimated $CO_2$ emission factor*
*NMVOC – NMVOC emissions (kt)*

*Emission factors*

$CO_2$ emission factors from additional raw materials use in glass production processes were taken from reports of glass production plants submitted within EU ETS and from applications to GHG permits. These are plant specific emission factors. Emission factors of limestone and dolomite use in production of glass as well soda ash use in glass production are default ones taken from IPCC 1996 (Table 4.15).

**Table 4.15 Emission factors for materials use in glass production (t emissions / t product or raw material)**

| | 1990 – 2014 |
|---|---|
| **Fluorspar use** | 0.0017 |
| **Potash use** | 0.32 |
| **Barium carbonate (witherite) use** | 0.223 |
| **Butylacetate use (NMVOC)[39]** | 1.0 |
| **Limestone use** | 0.440 |
| **Dolomite use** | 0.477 |
| **Soda ash use** | 0.415 |

For $CO_2$ emission from glass fibre production estimation 80% of carbon content conversion factor are used. According to 2006 IPCC Guidelines[40], indirect emissions of $CO_2$ from atmospheric oxidation of emitted NMVOC are calculated and reported in the inventory. The average amount of carbon in NMVOC is assumed to be 80%[41].

The $CO_2$ emission factor from 2006 IPCC Guidelines was estimated using following equation:

$$EF_{CO_2} = 80\% \text{ x } 44.0098/12.011$$

*where:*
*$EF_{CO2}$ – $CO_2$ emission factor (kt/kt)*
*80% – the average amount of carbon in NMVOC*
*44.0098 / 12.011 – carbon dioxide and carbon molmass ratio*

This leads to an emission factor for indirect $CO_2$ release of 2.931299642 kg $CO_2$/kg NMVOC.

*Activity data*

Amount of raw materials used in glass production is quite small and fluctuates in whole time series. Although use of potash increased sharply in 2004-2005, the use stopped in 2005 due to closure of glass production plant (Table 4.16).

**Table 4.16 Activity data for raw materials use in glass production 1990-2014 (kt)**

| | Use of potash | Use of fluorspar | Use of barium carbonate | Use of butylacetate | Use of dolomite | Use of limestone | Soda ash use |
|---|---|---|---|---|---|---|---|
| | kt | | | | | | |
| **1990** | NO | NO | NO | 0.001 | NO | 0.800 | NO |
| **1995** | NO | 0.116 | NO | 0.002 | 1.697 | 4.425 | 1.549 |

[39] *For emission estimation only for year 1990-1996, since 1997 the plant reported data from national database "2-AIR" is used*
[40] *http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_7_Ch7_Precursors_Indirect.pdf (page 7.6)*
[41] *Basing of the most often used average carbon conversion factor*

| | Use of potash | Use of fluorspar | Use of barium carbonate | Use of butylacetate | Use of dolomite | Use of limestone | Soda ash use |
|---|---|---|---|---|---|---|---|
| | kt | | | | | | |
| **2000** | NO | 0.084 | NO | NO | 2.875 | 6.133 | 4.200 |
| **2005** | 0.038 | 0.265 | 0.012 | NO | 2.088 | 7.070 | 3.743 |
| **2006** | 0.020 | 0.222 | 0.021 | NO | NO | 4.991 | 1.122 |
| **2007** | 0.009 | 0.201 | 0.010 | NO | NO | 9.899 | 0.090 |
| **2008** | NO | 0.255 | NO | NO | NO | 9.073 | NO |
| **2009** | NO | 0.408 | NO | NO | NO | 5.853 | NO |
| **2010** | NO | 0.622 | NO | NO | NO | 10.072 | NO |
| **2011** | NO | 0.591 | NO | NO | NO | 9.726 | NO |
| **2012** | NO | 0.639 | NO | NO | NO | 8.475 | 0.095 |
| **2013** | NO | NO | NO | NO | NO | 6.766 | 0.745 |
| **2014** | NO | NO | NO | NO | NO | 1.260 | 0.883 |

Activity data fluctuates in whole time series. Considerable decrease occur in the beginning of 1990s as a consequence of changes in structure of country's national economy. Dolomite use in glass production ended in 2005 as one glass production plant stopped it`s activity. The total amount of raw material used was affected by the closing of glass production plant and suspending of activity of another glass production plant.

In 2008-2012, only use of fluorspar in glass fibre production plant is occurring as other two glass production plants or either stopped its activity or suspended it. In 2013-2014 only limestone and soda ash as raw materials in glass production are used.

#### 4.2.4.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The uncertainty of activity data for this sector is assumed as 2% as plant specific reported data is used. Accredited verifiers and Latvia's Regional Environmental Boards verify the activity data reported in production plant's annual GHG reports within EU ETS so the activity data is adequately verified.

As default emission factors for limestone, dolomite and soda ash use are used the uncertainty is assumed 50%.

Other $CO_2$ emission factors for this sector are taken from glass production plant so the uncertainty could be assumed as quite low. Still the estimation of the emission factor can't be adequately verified so the uncertainty is assumed as quite high – 70%.

The combined $CO_2$ emission factor uncertainty for this sector is 86%.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions with exception of $CO_2$ emissions for use of fluorspar and potash as well as NMVOC emissions for glass fibre production are not estimated due to lack of estimation methodology.

Time series consistency was checked by verifying IEF, AD and emission changes and attention was paid to important increase/decrease that are explained in NIR.

#### 4.2.4.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

QA/QC check is performed with Tier1 method from IPCC GPG 2000.

Activity data, $CO_2$ emission factors and estimated emissions from glass production plants are taken from the annual GHG reports that plants submit within EU ETS. All GHG reports are verified by the ISO accredited verifiers that checks that all reported information is correct and corresponds to certain requirements from the legislation. Regional Environmental Boards also check the annual GHG reports and approves the report if everything reported is correct.

Checks performed pursuant to Article 7(1)(l) of Regulation (EU) No 525/2013 are done to comparing EU ETS data with GHG inventory emissions. There are differences in this sector in 2013 and 2014 due to fact that in the GHG inventory there are not taken into account $CO_2$ emissions from soda that is used for waste water nautralization but are taken into account soda that are used for glass smelting. Differences are represented in Table 4.17.

**Table 4.17 Differences between $CO_2$ emissions under ETS and inventory data of glass production for 2013 and 2014**

| 2.A.3 Glass production | | | Difference |
|---|---|---|---|
| Year | IPCC methodology IPCC 2000 GPG Volume 3 Chapter 3 equation 3.6B | Monitoring and reporting Regulation[42] Annex IV section 11 | |
| 2013 | 3.28 kt | 3.91 kt | 19.02% |
| 2014 | 0.92 kt | 1.55 kt | 68.22% |

#### 4.2.4.5 Category-specific recalculations

For submission 2016 $CO_2$ emissions from soda ash use in 2012-2014 are also included as high SiO content technological installation were set up that helps to detect used amount of soda ash. Recalculations are presented in Table 4.18.

**Table 4.18 Recalculations of $CO_2$ emissions including soda ash for years 2012-2014 (kt)**

| | $CO_2$ emissions without soda ash (kt) | Total $CO_2$ emissions from glass production (kt) | Difference (kt) |
|---|---|---|---|
| **2012** | 3.737 | 3.776 | 0.039 |
| **2013** | 2.984 | 3.293 | 0.309 |
| **2014** | 0.576 | 0.943 | 0.366 |

[42] *http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0601&from=EN*

#### 4.2.4.6 Category-specific planned improvements

No improvements are planned.

### 4.2.5 Ceramics (2.A.4.a)

#### 4.2.5.1 Category description

Under Ceramics sector $CO_2$ emissions from bricks and tiles production are reported.

Ceramics sector emissions amounts to 10.8 kt (1.3%) of total IPPU emissions in Latvia in 2014.

$CO_2$ emissions from 2.A.4.a sector are decreased by 84.3% since 1990 and increased by 19.7% comparing with 2013 (Figure 4.7).

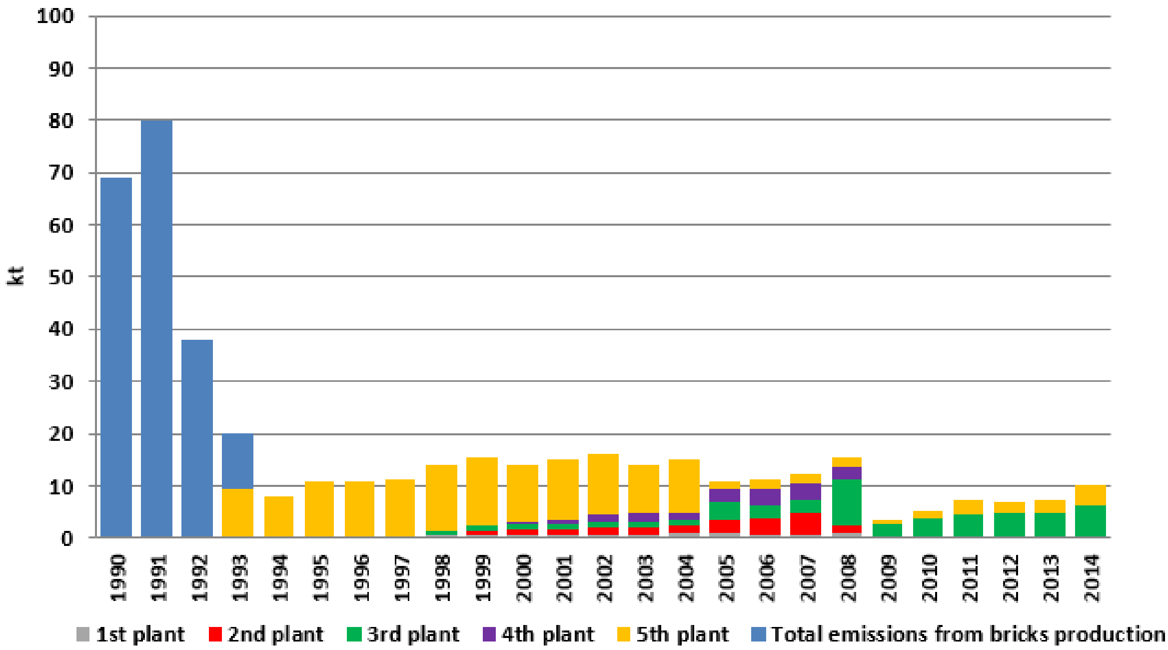


**Figure 4.7 $CO_2$ emissions from bricks and tiles production 1990-2014 (kt)**

Bricks production has strong traditions in Latvia as production plants operate many decades, for example in bricks production plant "LODE" the brick production was started in 1964. Still from 5 now operating bricks production plants only two were operating up to 1990. There is no information if the other companies were working for time period 1990-1993 what is not covered by GHG permit application requirements.

Only plants No 1 and No 5 were operating in time period 1990-1993 so the indicator IE was previously used for both these plants in time period 1990-1993. As it was not possible to obtain the data for raw materials used in Bricks production companies No 1 and No 5, there wasn't possible to estimate the emissions using the same methodology for 1993-2008 and to follow the consistency. Therefore the $CO_2$ emissions were estimated only using total produced bricks amount for 1990-1993 for these two plants. And after 1993 it was possible to increase methodology level and estimate $CO_2$ emissions for each plant separately.

There is only one tiles production plant in Latvia and $CO_2$ emissions from use of clay in tile production process in 1995-2014 are reported in 2.A.4.a sector. The tiles production plant and all bricks production plants are participants of EU ETS so the data from plant's annual GHG reports is available for inventory.

Emissions are decreasing since 2005 with some fluctuation due to decrease of activity of tiles production plant. Still in 2009 the $CO_2$ emissions have decreased approximately 4 times as the building and construction sector became inactive. In 2010 activity of tiles and bricks production is increased by 62.76%. From 2010-2014 activity of ceramics production is increased about 88.61%. Due to demand of such production in market in 2014 there is increased produced ceramics about 42.66% (Figure 4.7).

#### 4.2.5.2 Methodological issues

Emissions from used carbonates, additives and clay in tiles and bricks production are included in the sub category ceramics.

Emissions from this sector are calculated by multiplying emission factors with activity data. Activity data are collected mainly directly from the tiles and bricks producers but industrial statistics have also been used to calculate emissions for years 1990-1993.

The emission factors are mainly default ones but they depend on carbon content and overall composition of raw materials. This information is available and reported by producers under EU ETS. Mostly there is used methodology from Monitoring Reporting Regulation.

Information about methodology used in ceramics production is presented in NIR Annex 3.6.

#### 4.2.5.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The uncertainty of activity data for this sector is assumed as 2%. The activity data reported in production plant's annual GHG reports within EU ETS is verified by accredited verifiers and Latvia's Regional Environmental Boards so the activity data is adequately verified.

$CO_2$ emission factors used in emission calculation from tiles production are the default from MRG so the uncertainty of emission factors is assumed as 50%.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. Only $CO_2$ emissions from tiles and bricks production are estimated. Other emissions are not estimated due to lack of official emission estimation methodology and emission factors.

The uncertainty of activity data for the bricks production sector is assumed as 10% although the plants' reported data is used. Plants are used several emission estimation methodologies and for some historical years the reported data seems to be less reliable.

$CO_2$ emission factors used in emission calculation from bricks and tile production are the default ones from Monitoring and Reporting Regulation within EU ETS[43] so the uncertainty of emission factors is assumed as 50%.

For years 1990-1992 and 1993-2008 two different emission estimation methodologies are used still the time series is assumed as consistent as for 1990-1992 default Tier1 methodology is used but for 1993-2008 already plant specific emission estimation methodology assumed as Tier2 level is used.

For time period 1993-2008 two different methodologies are used for 3rd bricks production plant so that could lead to inconsistent time series although it is assumed that these are plant specific data and there is no need to recalculate them with using default emission factors or average carbonates content data.

Time series consistency was checked by verifying IEF, AD and emission changes and attention was paid to important increase/decrease that are explained in NIR.

#### 4.2.5.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

Activity data, $CO_2$ emission factor and estimated emissions are taken from the annual GHG reports that tiles production plant submit within EU ETS.

$CO_2$ emission factors for tiles production are taken from Monitoring Reporting Guidelines and are the default ones therefore there is no need to re-check correctness of emission factors.

QA/QC check is performed with Tier1 method from IPCC GPG 2000.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in national legislation. All findings were documented and introduced in GHG inventory. All corrections are archived.

All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Checks performed pursuant to Article 7(1)(l) of Regulation (EU) No 525/2013 are done to comparing EU ETS data with GHG inventory emissions. Such consistency checks are done in all IPPU sectors. There were no differences in this sector for 2013 and 2014.

#### 4.2.5.5 Category-specific recalculations

No recalculation has been done for the sector.

#### 4.2.5.6 Category-specific planned improvements

No improvements are planned in this sector.

[43] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF

### 4.2.6 Other Process Uses of Carbonates (2.A.4.d)

Under sector 2.A.4.d Other emissions of NOx, CO from cement production and NMVOC emissions from cement production and glass production are reported as it is not technically possible to report in CRF Reporter software these emissions under 2.A.1 Cement production sector and 2.A.3 Glass production sector directly. Detailed description about indirect emissions from cement production are included in NIR Chapter 4.2.2.2 Methodological issues.

In 2014 NMVOC emissions from 2.A.3 Glass production were calculated and added to 2.A.4.d as these emissions were calculated but not previously included in CRF Reporter as it was not technically possible to report under 2.A.3 Glass production sector directly. Therefore NMVOC emissions from Glass production are reported under sector 2.A.4.d and summed up with NMVOCs from cement production that are reported under this sector due to the same reason.

## *4.3 CHEMICAL INDUSTRY (CRF 2.B)*

### 4.3.1 Category description

Although there are strong traditions of the chemical industry in Latvia there are no chemical industry production processes listed in 2006 IPCC Guidelines or EMEP/EEA 2013 generating GHG emissions.

The biggest part of chemical industry is medicine production and then small part of paints and varnishes production.

In 2.B.10.a sector particular matters from phosphate fertilizers are calculated but these emissions are not reported under Climate Convention as GHGs.

There are no F-gases emissions under sectors 2.B.9.a By-Product Emissions and 2.B.9.2 Fugitive emissions so there are no child nodes added under these categories in CRF Reporter. Corresponding CRF tables are left blank due to CRF internal issue which does not allow to directly enter NO in green and grey cells without adding child nodes. It was confirmed by CRF help desk that this issue will be improved in the future releases of the software. Some F-gases data in the parent categories (green and grey cells) in corresponding CRF tables are missing due to this reason.

## *4.4 METAL INDUSTRY (CRF 2.C)*

$CO_2$, $CH_4$ and indirect GHG (NOx, CO, NMVOC, $SO_2$) from 2.C.1 Iron and Steel production are reporter under 2.C Metal Industry. There are no GHG emissions under rest of the sectors under 2.C. therefore these categories are NO in CRF Reporter.

There are no F-gases emissions under sectors 2.C.3. Aluminium production, 2.C.4. Magnesium production in Latvia therefore in CRF Reporter the corresponding CRF tables are left blank due to CRF internal issue which does not allow to directly enter NO in green and grey cells without adding child nodes. Some F-gases data in the parent categories (green and grey cells) in corresponding CRF tables are missing due to this reason.

### 4.4.1 Iron and Steel Production (CRF 2.C.1)

#### 4.4.1.1 Category category description

Metal industry sector emissions amounts to 0.01 kt $CO_2$ eq (0.001%) of total IPPU emissions in Latvia in 2014. $CO_2$ emissions from 2.C.1 sector have decreased by 100% since 1990 and by 99.9% comparing with 2013 (Figure 4.8 and Table 4.19).

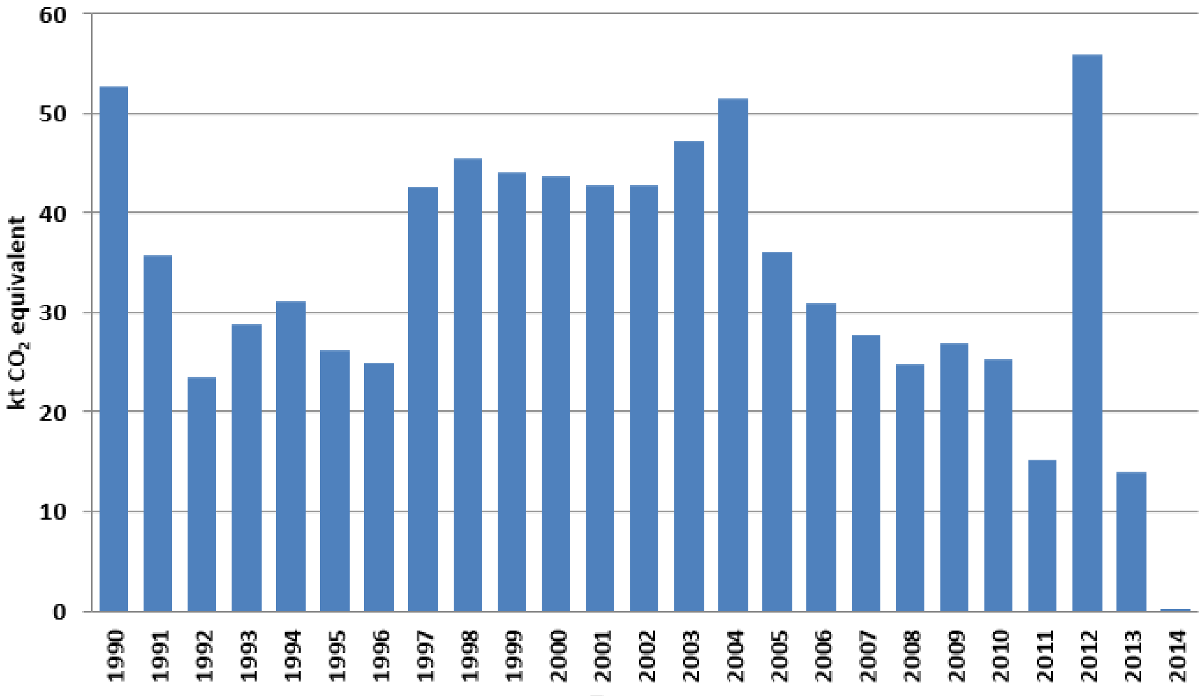


**Figure 4.8 $CO_2$ emissions from Metal industry 1990-2014 (kt $CO_2$ eq.)**

$CO_2$ emissions from crude iron as input material in iron and steel production in open-heart furnaces as well as crude iron used in electric arc furnaces are included in the inventory according to 2006 IPCC Guidelines excluding scrap metal use in crude steel production. The indirect GHG emission sources are also included under iron and steel production.

**Table 4.19 Emissions from 2.C Metal Production in 1990–2014 (kt)**

| | $CO_2$ | $CH_4$ | NOx | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|
| **1990** | 52.596 | 0.003 | 2.805 | 0.0006 | 0.011 | 0.088 |
| **1995** | 26.133 | 0.001 | 1.425 | 0.0003 | 0.006 | 0.045 |
| **2000** | 43.580 | 0.003 | 2.551 | 0.0005 | 0.010 | 0.080 |
| **2005** | 36.037 | 0.003 | 2.827 | 0.0006 | 0.011 | 0.089 |
| **2006** | 30.848 | 0.003 | 2.828 | 0.0006 | 0.011 | 0.089 |
| **2007** | 27.621 | 0.003 | 2.847 | 0.0006 | 0.011 | 0.089 |
| **2008** | 24.740 | 0.003 | 2.705 | 0.0005 | 0.011 | 0.085 |
| **2009** | 26.827 | 0.002 | 2.246 | 0.0004 | 0.009 | 0.070 |
| **2010** | 25.189 | 0.003 | 2.730 | 0.0005 | 0.011 | 0.086 |
| **2011** | 15.184 | 0.001 | 0.022 | 0.0002 | 0.008 | 0.010 |

| | $CO_2$ | $CH_4$ | NOx | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|
| **2012** | 55.872 | 0.004 | 0.109 | 0.0008 | 0.038 | 0.050 |
| **2013** | 13.900 | 0.001 | 0.025 | 0.0003 | 0.009 | 0.012 |
| **2014** | 0.010 | 0.000 | 0.000 | 0.0000 | 0.000 | 0.000 |
| **2014 versus 2013** | -99.9% | -100.0% | -100.0% | -99.9% | -100.0% | -100.0% |
| **2014 versus 1990** | -100.0% | -100.0% | -100.0% | -100.0% | -100.0% | -100.0% |

Considerable decrease occurred in time period 1990–1992 due to changes in Latvia's national economy (Table 4.19). Decrease of $CO_2$ emissions in 1990–1996 also occurred due to decrease of used crude iron in open-hearth furnaces (OHF) as $CO_2$ emissions are estimated only from crude iron use excluding used scrap metal part. It is explained with modification of production process when biggest part of primary and final steel products is produced by smelting of scrap metal.

$CO_2$ emissions increased almost twice in 2002–2003 when amount of used crude iron increased but amount of used scrap metal remains in same level. Final amount of steel products produced in the only metal industry facility fluctuates in small range in latest years. After the crisis in 2008-2009 all emissions from Metal production are increased in 2010. In 2011 there are sharp decrease of emissions due to changing technology of metal production, so also decreased amount of steel produced in electric arc furnaces (EAF) (about 75.11%) and mass of steel produced in OHF (about 68.67 %). Since mid-2011 the OHF is not used in this company (the installations are dismantled). At the end of 2010 installation was dismantled and new one was set up. In 2011 plant was working only 4 months. All crude steel is produced from scrap metal only in EAF. In 2011-2013 entire amount of crude steel is produced in EAF only and plant worked only 5-7 months in a year. In 2014 only 0.09 kt crude steel were produced from scrap metal that caused 0.01036 kt $CO_2$ emissions. At the moment Steel production plant is in a process of insolvency.

### 4.4.1.2 Methodological issues

Reported emissions, calculation methods and type of emission factors for the 2.C Metal Industry in the Latvian inventory are summarized in Table 4.20.

**Table 4.20 GHG emission categories, methods and gases reported from 2.C**

| Category | Method used | Gases reported |
|---|---|---|
| **C. Metal Industry** | | |
| 1. Iron and Steel Production | Tier1,2 | $CO_2$, NOx, CO, NMVOC, $SO_2$ |

IPCC 1996, IPCC GPG 2000 Tier2, EMEP/CORINAIR 2009 and EMEP/EEA 2013 are used to calculate direct and indirect GHG emissions from the 2.C.1 Steel Production sector. There is only one Iron & Steel production plant in Latvia that produces crude steel by melting crude iron and not only by melting scrap metals. The plant is participant of EU ETS and submits their annual GHG reports to LEGMC. It is possible to obtain more accurate and complete activity data and emission factors from enterprise that is involved in the emission trading system. Till Submission 2008 $CO_2$ emissions from plant's GHG reports were taken to report emissions from crude steel production.

After the In-country review 2007 the $CO_2$ emissions were completely recalculated according to IPCC GPG 2000 as methodology of $CO_2$ emission estimation from Monitoring and Reporting Regulation[44] within EU ETS didn't correspond to production technology used in plant.

$CO_2$ emission estimations from crude steel production

IPCC GPG 2000 Tier2 method is based on estimation of carbon losses through the production processes when remaining carbon is emitted to air.

$CO_2$ emissions were estimated only from crude iron used. In steel production plant mostly steel is produced by melting scrap metal that doesn't produce $CO_2$ emissions by leaking carbon. The only amount of total produced steel is reported by steel production company that means that the total amount of steel produced by using crude iron and melting scrap metal is known. Therefore it is needed to estimate the crude steel amount that is produced only by using crude iron and that caused $CO_2$ emissions. This amount is then used as activity data.

Following equation from IPCC GPG 2000 is used to calculate $CO_2$ emissions from steel production:

$$Emissions_{crude\ steel} = (\text{Mass of Carbon in the Crude Iron used for Crude Steel Production} - \text{Mass of Carbon in the Crude Steel}) \times 44/12 + \text{Emission factor}_{EAF} \times \text{Mass of Steel Produced in EAF}$$

According to information reported by steel producer:

- Average carbon content of crude iron using in steel production is 3 – 4% in 1990-2006, 4% for 2007, 2009-2013 and 3% for 2008;
- Average carbon content of produced steel is 0.1 – 0.4% for 1990-2006, 0.3% for 2007-2008 and 0.2% for 2009-2013.

Carbon emitted from consumed electrodes in electric arc furnaces has to be taken into account. These emissions are estimated by multiplying emission factor with mass of steel produced in electric arc furnaces.

*Emission factors*

Till 2008 there were used default emission factor- 1.5 kg carbon per tonne of steel and after there are used data reported by steel production plant. There are used as far as possible plant provided activity data and emission factors and as possible applicable higher tier method according to available data.

*Activity data*

For year 1990-2006 the used amount of raw materials in different types of production installations – open-hearth furnaces and electric arc furnaces according to the data reported by CSB to LEGMC even though the data potentially are confidential. Total produced amount of crude steel was known without division into particular production installations. So it was

[44] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF

necessary to divide amount of crude steel produced in open-hearth furnaces and in electric arc furnaces. These amounts are estimated by using amount of raw materials used in open-hearth furnaces and electric arc furnaces (used raw materials in different furnaces related to total used raw materials) and the same percentage is related to amount of produced steel. Accordingly amount of steel produced in open-hearth furnaces and in electric arc furnaces is divided from total produced crude steel.

For years 2007-2008 the total produced crude steel amount as output by used production technologies in OHF and EAF was reported by plant but the plant couldn't report the used raw materials as input divided by production technologies. The steel producer reported that it's not possible to divide these two amounts, as plant doesn't do it.

So the used raw material amount in 2007-2009 was divided by the same percentage raw material divided in 2006:

- 99.59% of total used scrap metals were used in open hearth furnaces;
- 95.52% of total used crude iron was used in open hearth furnaces.

Since large amount of scrap metals is used in crude steel production it is necessary to exclude this amount from total crude steel amount and to estimate only the amount of crude steel that is produced from crude iron. It is estimated by using crude iron / scrap metal ratio since amounts of used scrap metal in open-hearth furnaces and used crude iron in the same furnaces are known. Then this ratio number is multiplied with amount of steel produced in open-hearth furnaces to estimate amount of crude steel produced directly from crude iron.

Coke, coke fine and carburizators in crude steel production process is used as reducing agent to decrease the carbon content in final produced crude steel. The coke is combusted in production process and emissions from coke use was previously reported in 1.A.2.a Iron & Steel sector of Energy sector. For submission 2016 there were made allocation of used coke, coke fine and carburizators from Energy sector to IPPU as only crude steel production plant use these high carbon content carburizators only for process not for combustion to get energy.

Data for $CO_2$ emission estimations from steel production are given in Table 4.21 below.

**Table 4.21 Data for estimation of $CO_2$ emissions from steel production**

| | **Crude steel production(t)** | **Used carburizators (coke, etc.) (t)** | % mass of steel produced in OHF | **Mass of steel produced in OHF(t)** | Used scrap metal in open hearth furnaces in steel production(t) | Crude iron used in open heart furnaces(t) | Crude iron/scrap metal ratio | % mass of steel produced in EAF | **Mass of steel produced in EAF(t)** | **Amount of crude steel in what production crude iron where involved(t)** | Carbon content in crude iron | Carbon content in crude steel | Use 1.5kg per tonne EAF for 2% crude iron | EF of carburizators (coke, etc.) | Conversion factor | **Total $CO_2$ emissions from steel production (kt)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1990** | **550000** | **11362.493** | 98.74% | **543074** | 537227 | 107732 | 20.05% | 1.26% | **6925.57** | **110293.41** | 3.50% | 0.25% | 0.0015 | 3.489 | 3.664 | **52.596** |
| **1995** | **279326** | **6207** | 98.72% | **275747** | 285015 | 37086 | 13.01% | 1.28% | **3578.85** | **36345.75** | 3.50% | 0.25% | 0.0015 | 3.489 | 3.664 | **26.133** |
| **2000** | **500292** | **10061** | 99.23% | **496434** | 503123 | 70637 | 14.04% | 0.77% | **3858.06** | **70239.54** | 3.50% | 0.25% | 0.0015 | 3.489 | 3.664 | **43.580** |
| **2005** | **554345** | **6757.14** | 98.94% | **548472** | 527950 | 104010 | 19.70% | 1.06% | **5872.56** | **109210.01** | 3.50% | 0.25% | 0.0015 | 3.489 | 3.664 | **36.037** |
| **2006** | **554546** | **5206.69** | 98.90% | **548419** | 531026 | 105769 | 19.92% | 1.10% | **6126.89** | **110453.68** | 3.50% | 0.25% | 0.0015 | 3.489 | 3.664 | **30.848** |
| **2007** | **558156** | **3731.081** | 99.76% | **556814** | 463940 | 109248 | 23.55% | 0.24% | **1342** | **131433.86** | 4.00% | 0.30% | 0.0015 | 3.489 | 3.664 | **27.621** |
| **2008** | **530462** | **4575.172** | 99.34% | **526964** | 492450 | 88319 | 17.93% | 0.66% | **3498** | **95136.30** | 3.00% | 0.30% | 0.0018 | 3.489 | 3.664 | **24.740** |
| **2009** | **440458** | **4950.337** | 99.90% | **440016** | 413058 | 68784 | 16.65% | 0.10% | **442** | **73346.75** | 4.00% | 0.20% | 0.0064 | 3.489 | 3.664 | **26.827** |
| **2010** | **535301** | **3985.918** | 99.79% | **534168** | 476868 | 81340 | 17.06% | 0.21% | **1133** | **91306.99** | 4.00% | 0.20% | 0.0061 | 3.489 | 3.664 | **25.189** |
| **2011** | **167624** | **3948.519** | NO | NO | NO | NO | 1.81% | 100.00% | **167624** | **167624** | 4.00% | 0.20% | 0.0018 | 3.489 | 3.664 | **15.184** |
| **2012** | **836431** | **15190.37** | NO | NO | NO | NO | 1.49% | 100.00% | **836431** | **836431** | 4.00% | 0.20% | 0.0014 | 3.489 | 3.664 | **55.872** |
| **2013** | **193190** | **3710.187** | NO | NO | NO | NO | 1.40% | 100.00% | **193190** | **193190** | 4.00% | 0.20% | 0.0030 | 3.489 | 3.664 | **13.900** |
| **2014** | **92.51** | **2.97** | NO | NO | NO | NO | 0.00% | 100.00% | **92.51** | **92.51** | 4.00% | 0.20% | NO | 3.489 | 3.664 | **0.010** |

$CH_4$ and indirect GHG emission estimations from crude steel production

*Methods*

The $CH_4$, NMVOC, CO, $NO_x$ and $SO_2$ emissions from iron and steel production are calculated at the LEGMC based on activity data from the CSB and steel production plant according to EMEP/CORINAIR 2007 and EMEP/EEA 2013 emission factors.

*Emission factors*

Emission factors of methane and indirect GHG emissions are taken from EMEP/CORINAIR 2007 methodology (Table 4.22).

**Table 4.22 Emission factors of metal production (t/t)**

| | $CH_4$ | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|
| **Iron and Steel Production** | | | | | |
| In open hearth furnace | 0.000005 | 0.0051 | 0.000001 | 0.00002 | 0.00016 |
| In electric arc furnace | 0.000005 | 0.00013 | 0.0017 | 0.000046 | 0.00006 |

Emission factors for $NO_x$, NMVOC and $SO_2$ emissions are taken from EMEP/EEA 2013 according to methodology for estimations of emissions from processes in open-hearth furnaces, where 95% of total steel production is produced till 2010 and for electric arc furnace starting from year 2011.

It has to be noted that for $CH_4$, NMVOC, CO, $NO_x$ and $SO_2$ emissions estimations total produced crude steel data is used but for $CO_2$ emission estimation only crude steel produced from crude iron is taken into account and reported in CRF Reporter.

#### 4.4.1.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Only one enterprise operates in iron and steel industry category in Latvia and this facility reports data of production and raw materials used in production processes. Still used raw materials data divided by technological processes aren't available and are estimated by using approximate percentage. So the uncertainty of activity data of iron and steel industry is assumed 25%.

$CO_2$ emission factor is estimated according to plant specific data reported by steel producer using IPCC GPG 2000 equations so the uncertainty of $CO_2$ emission factor is assumed as 5%.

Uncertainty of $CH_4$ emission factor taken from EMEP/CORINAIR 2007 methodologies is assigned as 10% so it is apposite for open-hearth furnaces – technology mainly used in facility operated in iron and steel industry in Latvia till 2010. After there are produced all steel in electric arc furnaces.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. GHG emissions from all sectors are estimated or reported as not occurring / not applicable therefore there are no "not estimated" sectors.

Time series consistency was checked by verifying IEF, AD and emission changes and attention was paid to important increase/decrease that are explained in NIR.

#### 4.4.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

QA/QC check is performed with Tier1 method from 2000 IPCC GPG.

All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in national legislation. All findings were documented and introduced in GHG inventory. All corrections are archived.

All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Checks performed pursuant to Article 7(1)(l) of Regulation (EU) No 525/2013 are done to comparing EU ETS data with GHG inventory emissions. There are differences in sector 2.C.1 in 2013 and 2014 between ETS and inventory data. See Table 4.23 below.

**Table 4.23 Differences between $CO_2$ emissions under ETS and inventory data of steel production for 2013 and 2014**

| 2.C.1 Iron and Steel | | | Difference |
|---|---|---|---|
| Year | IPCC methodology IPCC 2000 GPG Volume 3 Chapter 3 equation 3.6B | Monitoring and reporting Regulation[45] Art.25 | |
| 2013 | 13.900 kt | 14.072 kt | 1.22% |
| 2014 | 0.01036 kt | 0.0109 kt | 5.18% |

Difference is caused by different emission calculation methodologies that are used under UNFCCC reporting (IPCC GPG 2000 and 2006 IPCC Guidelines) and European Union Emission Trading system (EU ETS) reporting. According to IPCC 2000 GPG the $CO_2$ emissions from 2.C.1 are estimated taking into account only particular part of used raw materials that generate $CO_2$ emissions in production process. As mostly scrap metals are used in production of crude steel in Latvia, only amount of used crude iron as input material in crude steel production is taken into account. During remelting of scrap metal the $CO_2$ emissions are not generated. The crude iron/ scrap metal ratio is used in emission calculation.

Under EU ETS $CO_2$ emissions by plant are calculated by multiplying AD (used raw materials) with EF without any division into used technologies that gives very approximately calculated $CO_2$ emissions that differ from emissions reported in GHG inventory.

[45] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0601&from=EN

#### 4.4.1.5 Category-specific recalculations

For 2.C.1 sector $CO_2$ emissions of used carburizators (coke, coke fine) was taken into account and recalculations are done in all time series. These emissions was previously reported in Energobalance and under Energy sector and multiplied with different emission factor. Recalculations are represented in Table 4.24.

**Table 4.24 Recalculations made in 2.C.1**

| | $CO_2$ emissions without carburizators (kt) | Total $CO_2$ emissions from steel production (kt) | Difference (kt) |
|---|---|---|---|
| **1990** | 12.816 | 52.596 | 39.644 |
| **1991** | 8.703 | 35.717 | 26.921 |
| **1992** | 5.728 | 23.509 | 17.720 |
| **1993** | 7.000 | 28.726 | 21.652 |
| **1994** | 6.546 | 31.158 | 24.545 |
| **1995** | 4.429 | 26.133 | 21.656 |
| **1996** | 3.482 | 24.875 | 21.360 |
| **1997** | 7.993 | 42.555 | 34.524 |
| **1998** | 8.499 | 45.367 | 36.830 |
| **1999** | 7.709 | 44.011 | 36.272 |
| **2000** | 8.421 | 43.580 | 35.103 |
| **2001** | 8.037 | 42.685 | 34.593 |
| **2002** | 7.597 | 42.816 | 35.166 |
| **2003** | 12.160 | 47.090 | 34.890 |
| **2004** | 12.904 | 51.404 | 38.379 |
| **2005** | 12.347 | 36.037 | 23.576 |
| **2006** | 12.562 | 30.848 | 18.166 |
| **2007** | 14.569 | 27.621 | 13.018 |
| **2008** | 8.726 | 24.740 | 15.963 |
| **2009** | 9.547 | 26.827 | 17.272 |
| **2010** | 11.260 | 25.189 | 13.907 |
| **2011** | 0.302 | 15.184 | 14.468 |
| **2012** | 1.171 | 55.872 | 52.999 |
| **2013** | 0.585 | 13.900 | 12.945 |
| **2014** | NO | 0.010 | 0.000 |

#### 4.4.1.6 Category-specific planned improvements

No improvements are planned in this sector.

## *4.5 NON-ENERGY PRODUCTS FROM FUELS AND SOLVENT USE (CRF 2.D)*

Under 2.D Non-energy Products from Fuels and Solvent Use sector there are reported emissions from Paraffin wax, Lubricant use and Other (including Solvent use, Asphalt roofing and Road paving with asphalt, urea use).

Non-energy products from fuels and solvent use sector GHG emissions amounts to 46.33 kt (0.4%) of total $CO_2$ equivalent emissions without LULUCF in Latvia in 2014. $CO_2$ emissions from 2.D sector are decreased about 28.0% since 1990 and by 6.2% comparing with 2013 (Figure 4.9). The main part of this sector emissions constitute 2.D.3 Other subsector with 33.12 kt (71.5%) from total 2.D sector emissions. 2.D.3 Other subsector includes emissions from Solvent use, Asphalt roofing, Road paving with asphalt and Urea use. Solvent use sector constitutes 97.2% of 2.D.3 Other sector. Remaining part of emissions (2.8%) from 2.D.3 Other constitute Asphalt roofing, Road pawing with asphalt and Urea Use.

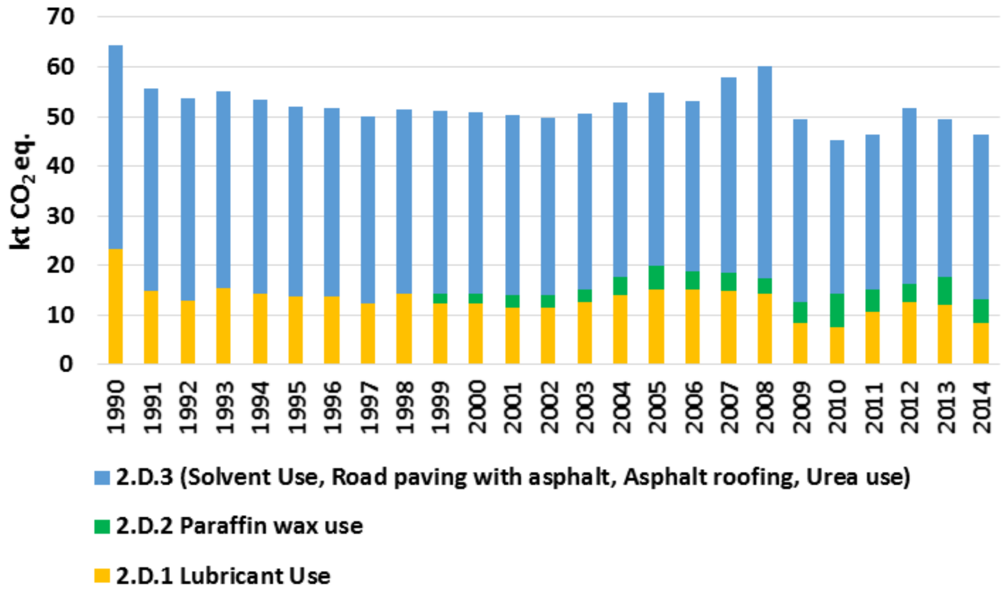


**Figure 4.9 Emissions from Non-energy Products from Fuels and Solvent Use sector 1990-2014[46] (kt $CO_2$ eq.)**

Reported emissions, calculation methods and type of emission factors for the 2.D Non-energy Products from Fuels and Solvent Use in the Latvian inventory are summarized in Table 4.25.

**Table 4.25 GHG emission categories, methods and gases reported from 2.D**

| Category | Method used | Gases reported |
|---|---|---|
| D. Non-energy Products from Fuels and Solvent Use | | |
| 1.Lubricant Use | Tier1 | $CO_2$ |
| 2. Paraffin Wax Use | Tier1 | $CO_2$ |
| 3. Other | | |
| Solvent Use | Tier1,2 | $CO_2$, NMVOC |
| Road paving with asphalt | Tier1 | $CO_2$, NMVOC |
| Asphalt roofing | Tier1 | $CO_2$, NMVOC, CO |
| Urea use | Tier1 | $CO_2$ |

## 4.5.1 Lubricant Use (CRF 2.D.1)

### 4.5.1.1 Category description

Lubricant use subsector emissions amounts 8.3 kt (17.9%) of total Non-energy sector products` emissions in Latvia in 2014. $CO_2$ missions from 2.D.1 sector decreased by 64.3% since 1990 and decreased by 31.0% comparing with 2013 (Figure 4.10 and Table 4.26).

[46] *2.D.1 Lubricant Use and 2.D.2 Paraffin Wax Use on secundary axis*

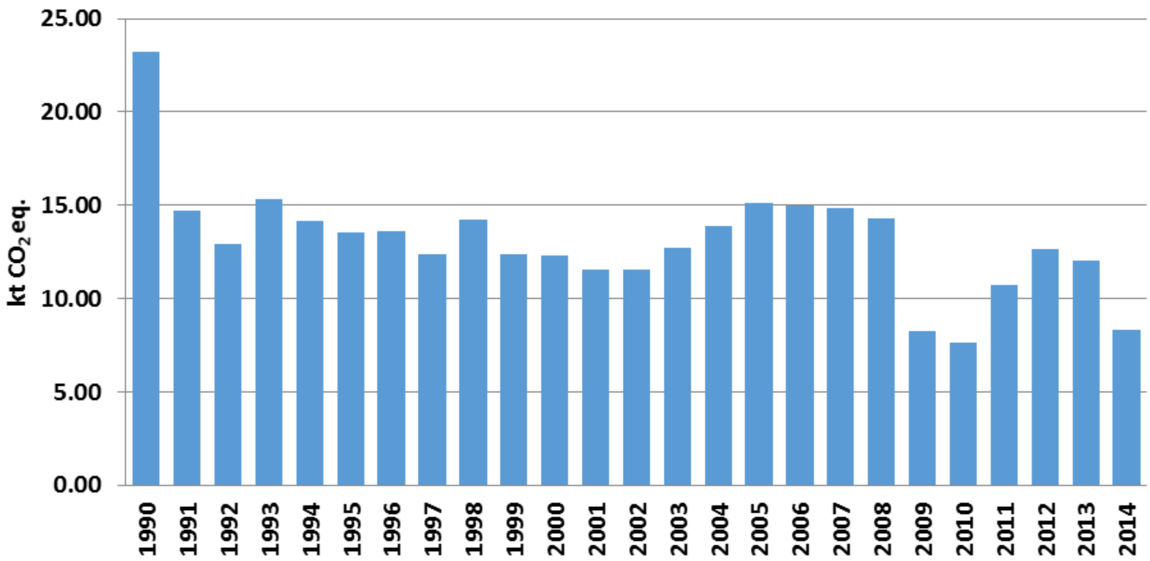


**Figure 4.10 $CO_2$ emissions from Lubricant use 1990-2014 (kt)**

Under this category lubricant consumption are reported as feed stocks in Latvia. Emissions from lubricant is reported as „$CO_2$ not emitted" because it is assumed that $CO_2$ emissions is captured and not emitted to the air.

Consumption and emissions of lubricants are reported in sector 2.D.1 for all years in time series 1990-2014 (Table 4.26).

**Table 4.26 $CO_2$ emissions from lubricant use 1990-2014**

| | $CO_2$ emissions (kt) |
|---|---|
| **1990** | 23.25 |
| **1995** | 13.57 |
| **2000** | 12.31 |
| **2005** | 15.09 |
| **2006** | 14.99 |
| **2007** | 14.86 |
| **2008** | 14.31 |
| **2009** | 8.28 |
| **2010** | 7.62 |
| **2011** | 10.73 |
| **2012** | 12.66 |
| **2013** | 12.03 |
| **2014** | 8.30 |
| **Share in IPPU total in 2014** | 1.0% |
| **2014 versus 2013** | -64.3% |
| **2014 versus 1990** | -31.0% |

### 4.5.1.2 Methodological issues

Emission factors

$CO_2$ emissions are calculated according to Tier 1 method and emission factors as well as default carbon content are taken from 2006 IPCC Guidelines. Carbon content for lubricant is

20.0 kg/GJ as default one taken from 2006 IPCC Guidelines Volume 2 Energy Chapter 1 Table 1.3.

Net calorific value (NCV) for lubricants is 41.86 TJ/$10^3$ t and is reported in energobalance[47] from Central Statistical Bureau (CSB) of Latvia.

$CO_2$ emissions are calculated using 2006 IPCC Guidelines equation 5.2[48]:

$$CO_2\ Emissions = LC \times CC_{Lubricant} \times ODU_{Lubricant} \times 44/12$$

*where:*
*$CO_2$ emissions= $CO_2$ Emissions from lubricants, tonne $CO_2$*
*LC= Total lubricant consumption, TJ*
*$CC_{Lubricant}$=carbon content of lubricants (default), tonneC/TJ (=kg/ C/TJ)*
*$ODU_{Lubricant}$ =ODU(Oxidised during use) factor (based on default composition of oil and grease) fraction*
*44/12= mass ratio of $CO_2$/C*

*Activity data*

Activity data prepared by CSB and reported to EUROSTAT in EUROSTAT Annual Questionnaire formats were used.

Lubricants are mainly used in Transport sector. According to Transport sector expert the percentage of lubricants that are combusted in mobile vehicles system was estimated. Approximately 99.7% in 2010-2013 from total lubricants consumption are used as feedstocks and therefore 99.7% of carbon is reported as stored. Only 0.3% of total lubricant consumption is assumed as combusted and the emissions for the activity are included in Road Transport sector.

**Table 4.27 Activity data for lubricant use 1990-2014**

| | Consumption of lubricants (TJ) | Net calorific value for lubricants (TJ/$10^3$t) |
|---|---|---|
| **1990** | 1632.54 | 41.86 |
| **1995** | 962.78 | 41.86 |
| **2000** | 879.06 | 41.86 |
| **2005** | 1088.36 | 41.86 |
| **2006** | 1088.36 | 41.86 |
| **2007** | 1088.36 | 41.86 |
| **2008** | 1046.5 | 41.86 |
| **2009** | 627.9 | 41.86 |
| **2010** | 586.04 | 41.86 |
| **2011** | 795.34 | 41.86 |
| **2012** | 920.92 | 41.86 |
| **2013** | 879.06 | 41.86 |
| **2014** | 627.9 | 41.86 |

[47] http://data.csb.gov.lv/pxweb/lv/vide/vide__ikgad__energetika/EN0020.px/?rxid=a7ccdc56-327e-45d0-9488-41a1f701ae14
[48] *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5: Non-Energy Products from Fuels and Solvent Use, p.5.7*

#### 4.5.1.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

As the default ODU factor is used, the uncertainty (50%) from 2006 IPCC Guidelines is applied for ODU emission factor.

The carbon content coefficients is taken from 2006 IPCC Guidelines and are based on two studies of the carbon content and heating value of lubricants, from which an uncertainty range of about 3%.

Activity data are taken from CSB of Latvia and uncertainty are assumed as 2%.

#### 4.5.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

QA/QC check is performed according to 2006 IPCC Guidelines. There are compared the amounts discarded, recovered and combusted in Transport sector with total consumption figures in the calculation to check the internal consistency data and ODU factors if they are used in the calculation of different source categories across sectors.

#### 4.5.1.5 Category-specific recalculations

During quality control procedures mistake in $CO_2$ emission calculation were found and therefore emissions were recalculated for all time series.

#### 4.5.1.6 Category-specific improvements

No specific improvements are planned in this sector.

### 4.5.2 Paraffin Wax Use (CRF 2.D.2)

#### 4.5.2.1 Category description

Paraffin wax use subsector emissions amounts to 4.91kt (10.6%) of total Non-energy sector emissions in Latvia in 2014. $CO_2$ emissions from 2.D.2 sector have been increased by 166.7% since 1999  and decreased by 11.1% comparing with 2013 (Figure 4.11 and Table 4.28).

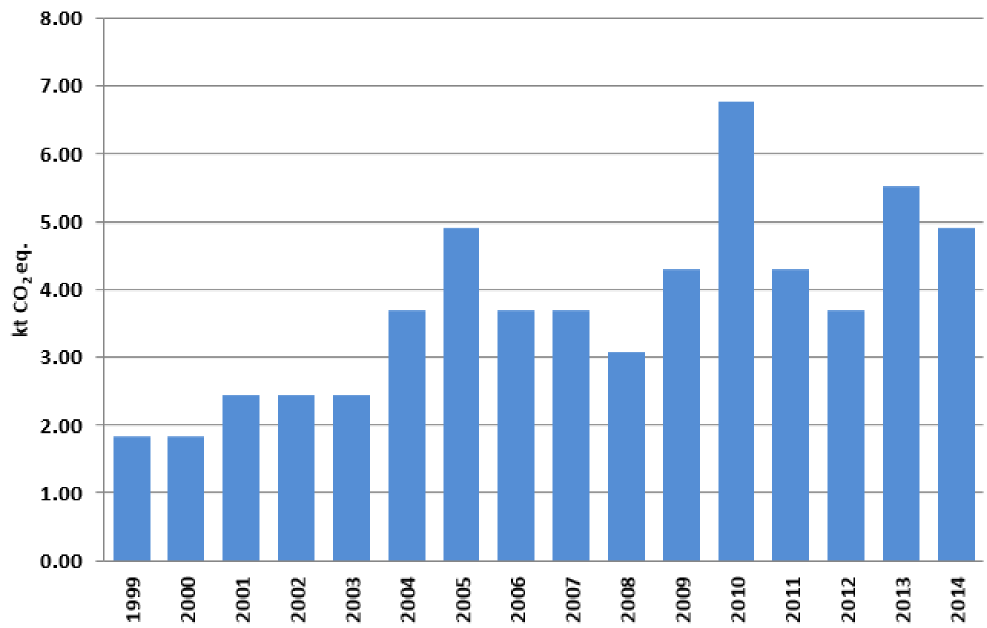


**Figure 4.11 $CO_2$ emissions from Paraffin wax use 1990-2014 (kt)**

Under this category paraffin wax consumption is reported as feedstocks in Latvia. Paraffin wax mainly is used in chemical substances and chemical production as well as plastic, rubber and furniture production. Emissions from paraffin wax is reported as „$CO_2$ not emitted" because it is assumed that $CO_2$ emissions is captured and not emitted into the air.

Consumption and emissions of paraffin wax are reported in sector 2.D.2 for all years in time series 1999-2014 (Table 4.28).

**Table 4.28 $CO_2$ emissions from paraffin wax use 1990-2014**

| | $CO_2$ emissions (kt) |
|---|---|
| **1990** | NO |
| **1995** | NO |
| **2000** | 1.84 |
| **2005** | 4.91 |
| **2006** | 3.68 |
| **2007** | 3.68 |
| **2008** | 3.07 |
| **2009** | 4.30 |
| **2010** | 6.75 |
| **2011** | 4.30 |
| **2012** | 3.68 |
| **2013** | 5.52 |
| **2014** | 4.91 |
| **Share in IPPU total in 2014** | 10.6% |
| **2014 versus 2013** | -11.1% |
| **2014 versus 1999** | 166.7% |

#### 4.5.2.2 Methodological issues

*Emission factors*

$CO_2$ emissions are calculated according to Tier1 method and emission factors as well as default carbon content are taken from the 2006 IPCC Guidelines. Carbon content for paraffin wax is 20.0 kg/GJ as default one taken from 2006 IPCC Guidelines Volume 2 Energy Chapter 1 Table 1.3.

Net calorific value (NCV) for lubricants is 41.86 TJ/$10^3$ t and is reported in Energy Balance from CSB[49].

$CO_2$ emissions are calculated using 2006 IPCC Guidelines equation 5.4[50]:

$$CO_2\ Emissions = PW \times CC_{Wax} \times ODU_{Wax} \times 44/12$$

*where:*
*$CO_2$ emissions= $CO_2$ Emissions from waxes, tonne $CO_2$*
*LC= Total wax consumption, TJ*
*$CC_{Wax}$=carbon content of paraffin wax (default), tonneC/TJ (=kg/ C/TJ)*
*$ODU_{Wax}$= Oxidised during use (ODU) factor for paraffin wax, fraction*
*44/12= mass ratio of $CO_2$/C*

*Activity data*

Activity data prepared by CSB and reported to EUROSTAT in EUROSTAT Annual Questionnaire formats were used. Data from statistics about paraffin wax consumption are available only from 1999.

**Table 4.29 Activity data from paraffin wax use 1990-2014**

| | Consumption of paraffin wax (TJ) | Net calorific value for paraffin wax (TJ/$10^3$t) |
|---|---|---|
| **1990** | NO | 41.86 |
| **1995** | NO | 41.86 |
| **2000** | 125.58 | 41.86 |
| **2005** | 334.88 | 41.86 |
| **2006** | 251.16 | 41.86 |
| **2007** | 251.16 | 41.86 |
| **2008** | 209.3 | 41.86 |
| **2009** | 293.02 | 41.86 |
| **2010** | 460.46 | 41.86 |
| **2011** | 293.02 | 41.86 |
| **2012** | 251.16 | 41.86 |
| **2013** | 376.74 | 41.86 |
| **2014** | 334.88 | 41.86 |

[49] *http://data.csb.gov.lv/pxweb/lv/vide/vide__ikgad__energetika/EN0020.px/?rxid=a7ccdc56-327e-45d0-9488-41a1f701ae14*
[50] *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5: Non-Energy Products from Fuels and Solvent Use, p.5.11*

#### 4.5.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The default ODU factor for paraffin wax is taken from 2006 IPCC Guidelines. Due to lack of information regarding application of paraffin wax in the country, the uncertainty of ODU factor is assumed 100 %.

The carbon content coefficient is taken from 2006 IPCC Guidelines and uncertainty is 5%.

Activity data are taken from CSB of Latvia and uncertainty is assumed 2%.

#### 4.5.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Quality meetings are held annually between experts

QA/QC check is performed according to 2006 IPCC Guidelines. There are compared the amounts discarded, recovered and combusted with total consumption figures in the calculation to check the internal consistency data and ODU factors if they are used in the calculation of different source categories across sectors.

#### 4.5.2.5 Category-specific recalculations

During quality control procedures mistake in $CO_2$ emission calculation were found and therefore emissions were recalculated for all time series.

#### 4.5.2.6 Category-specific improvements

No specific improvements are planned in this sector.

### 4.5.3 Other (CRF 2.D.3)

#### 4.5.3.1 Category description

This chapter describes emissions from Solvent Use, Road paving with asphalt and Asphalt roofing sector under Other (CRF 2.D.3).

**Solvent Use**

Solvent Use sector (2.D.3) is a key source of indirect $CO_2$ emissions of Latvian inventory. The Solvent use is estimated as a key category in level by using Approach 1 without LULUCF. Quantitative information regarding key categories is available in Annex 1 of this submission.

The use of solvents and products containing solvents results in emissions of non-methane volatile organic compounds (NMVOC). NMVOC emissions are regarded as an indirect greenhouse gases as it over a period of time will oxidize into $CO_2$ when emitted to the atmosphere. The $CO_2$ emissions from Solvent Use sector have been constantly decreasing since the beginning of 1990s till 2006 mostly due to the industry was affected by a crisis.

According to 2006 IPCC Guidelines and EMEP/EEA 2013 Solvent Use sector covers emissions from the four SNAP (Selected Nomenclature for Air Pollution) subcategories:

- SNAP 0601: Paint application (Including such activities as paints and varnishes from decorative, industrial and other coating applications);
- SNAP 0602: Degreasing, Dry cleaning (Degreasing includes cleaning products from water-insoluble substances such as grease, fats, oils waxes and tars. Dry cleaning refers to any process to remove contamination from furs, leather, down leathers, textiles or other objects made of fibres using organic solvents);
- SNAP 0603: Chemical products manufacturing or processing (Including the processing of polyester, PVC, foams and rubber, manufacture of paints, inks, glues and adhesives and finishing of textile);
- SNAP 0604: Other use of solvents and related activities (Including such activities as "enduction" (i.e. coating) of glass wool and mineral, printing industry, fat and oil extraction, uses of glues and adhesives, wood preservation, domestic use (other than paint application) and vehicle underseal treatment and vehicle dewaxing).

Latvia`s reported NMVOC and indirect $CO_2$ emissions from NMVOC under Solvent Use sector in 2014 are shown in Table 4.30.

**Table 4.30 Reported emissions from Solvent Use in Latvia in 2012**

| CATEGORY | | TITLE | EMISSIONS |
|---|---|---|---|
| **SNAP** | NRF | | |
| **0601** | 2D3d | Paint application | NMVOC, indirect $CO_2$ |
| **0602** | 2D3e | Degreasing | NMVOC, indirect $CO_2$ |
| **0602** | 2D3f | Dry cleaning | NMVOC, indirect $CO_2$ |
| **0603** | 2D3g | Chemical products | NMVOC, indirect $CO_2$ |
| **0604** | 2D3h | Printing industry | NMVOC, indirect $CO_2$ |
| **0604** | 2D3a | Domestic solvent use (other than paint application) | NMVOC, indirect $CO_2$ |
| **0604** | 2D3i | Other solvent use | NMVOC, indirect $CO_2$ |

Solvent Use sector was the largest pollution source of NMVOC emissions in Latvia in 2014 and it covered over 32.8% (14.65 kt) from the total Latvia's NMVOC emissions. The main share of total indirect emissions contributed SNAP 0601: Paint application – 48.6% or 15.65 kt and SNAP 0604: Other use of solvents and related activities – 27.67% or 8.91 kt (Figure 4.12).

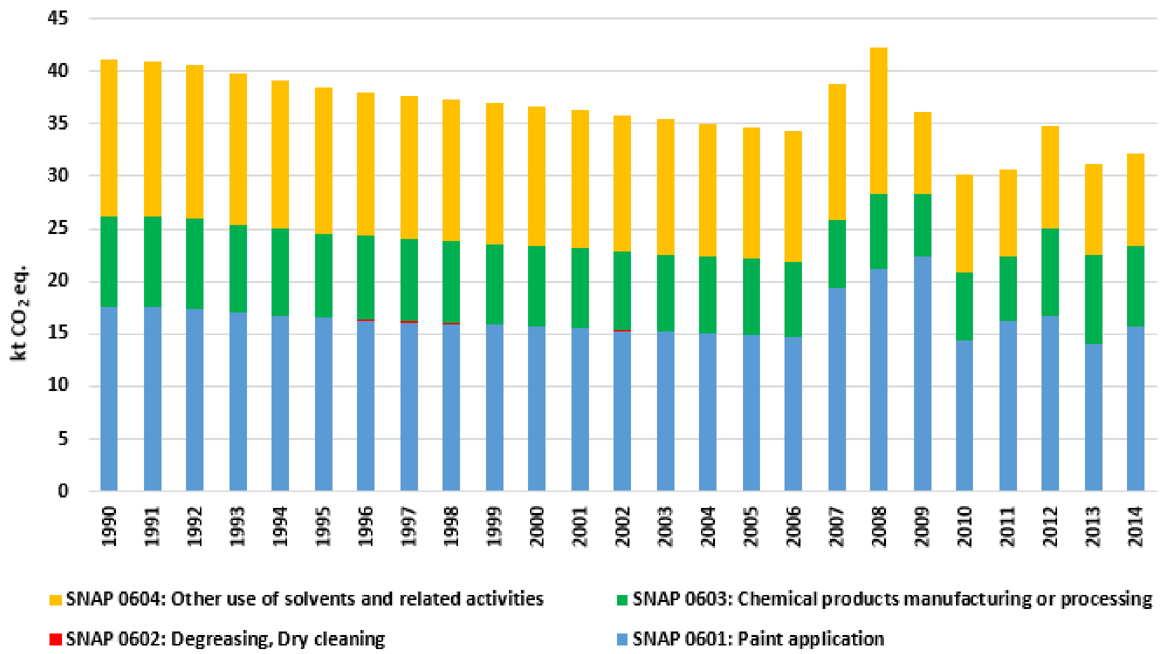


**Figure 4.12 Emissions from Solvent Use in 1990-2014 (kt $CO_2$ eq.)**

The $CO_2$ emissions from Solvent Use sector have been constantly decreasing since the beginning of 1990s till 2006 mostly due to the industry was affected by a crisis.

The emission increase in the period of 2006-2008 is explained with import growth of NMVOC containing products. In subsequent years there has been observed decrease back till 2010. At the end of 2008 the world was struck by the economic crisis which also affected the Solvent Use sector in Latvia.

As shown there is slight increase of $CO_2$ emissions of Solvent Use sector during the later period of 2010 till 2014 (except 2012 when rapid increase observed). For instance, emissions of $CO_2$ have decreased by 6.7 %, from 30.17 kt $CO_2$ in 2010 to 32.20 kt $CO_2$ eq in 2014 (see Table 4.31).

**Table 4.31 Indirect $CO_2$ emissions from Solvent Use in 1990-2014 (kt $CO_2$ eq.)**

| Indirect $CO_2$ | SNAP 0601: Paint application | SNAP 0602: Degreasing, Dry cleaning | SNAP 0603: Chemical products manufacturing or processing | SNAP 0604: Other use of solvents and related activities | Sum |
|---|---|---|---|---|---|
| **1990** | 17.58 | 0.03 | 8.61 | 14.85 | 41.06 |
| **1991** | 17.51 | 0.03 | 8.58 | 14.79 | 40.91 |
| **1992** | 17.41 | 0.03 | 8.53 | 14.71 | 40.68 |
| **1993** | 17.03 | 0.03 | 8.34 | 14.39 | 39.80 |
| **1994** | 16.74 | 0.03 | 8.20 | 14.14 | 39.11 |
| **1995** | 16.47 | 0.03 | 8.07 | 13.92 | 38.49 |
| **1996** | 16.27 | 0.03 | 7.97 | 13.74 | 38.01 |
| **1997** | 16.11 | 0.03 | 7.89 | 13.61 | 37.63 |
| **1998** | 15.95 | 0.03 | 7.81 | 13.47 | 37.26 |
| **1999** | 15.81 | 0.03 | 7.74 | 13.35 | 36.93 |
| **2000** | 15.66 | 0.02 | 7.67 | 13.23 | 36.59 |

| Indirect $CO_2$ | SNAP 0601: Paint application | SNAP 0602: Degreasing, Dry cleaning | SNAP 0603: Chemical products manufacturing or processing | SNAP 0604: Other use of solvents and related activities | Sum |
|---|---|---|---|---|---|
| **2001** | 15.50 | 0.02 | 7.59 | 13.10 | 36.22 |
| **2002** | 15.29 | 0.02 | 7.49 | 12.92 | 35.72 |
| **2003** | 15.15 | 0.02 | 7.42 | 12.80 | 35.39 |
| **2004** | 15.00 | 0.02 | 7.35 | 12.67 | 35.04 |
| **2005** | 14.82 | 0.02 | 7.26 | 12.52 | 34.62 |
| **2006** | 14.68 | 0.02 | 7.19 | 12.40 | 34.29 |
| **2007** | 19.30 | 0.03 | 6.53 | 12.85 | 38.71 |
| **2008** | 21.22 | 0.02 | 7.10 | 13.87 | 42.21 |
| **2009** | 22.29 | 0.02 | 6.08 | 7.79 | 36.18 |
| **2010** | 14.38 | 0.03 | 6.36 | 9.39 | 30.17 |
| **2011** | 16.21 | 0.03 | 6.11 | 8.28 | 30.64 |
| **2012** | 16.66 | 0.04 | 8.35 | 9.70 | 34.75 |
| **2013** | 14.07 | 0.06 | 8.33 | 8.74 | 31.19 |
| **2014** | 15.65 | 0.04 | 7.60 | 8.91 | 32.20 |

It is assumed that the NMVOC containing products imported in the country in a particular year are utilized in the same year as the data of the actual use is not available or is confidential. At the same time enterprises tend to provide a stockpiles taking into account economic situation. This in turn affects amount of $CO_2$ emission, causing fluctuations of time series.

**Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)**

In this sector emissions from construction materials production as well as Road paving activities are reported.

**Table 4.32 Activity data for Road paving and Asphalt roofing 1990-2014**

| | Amount of bitumen mixtures used (kt) | % of asphalt used for Road Paving | % of asphalt used for Asphalt roofing | Road Paving with asphalt (kt) | Asphalt roofing (kt) |
|---|---|---|---|---|---|
| **1990** | 39.000 | 80% | 20% | 31.200 | 7.800 |
| **1995** | 116.990 | 80% | 20% | 93.592 | 23.398 |
| **2000** | 423.643 | 90% | 10% | 381.278 | 42.364 |
| **2005** | 1165.015 | 90% | 10% | 1048.514 | 116.502 |
| **2006** | 1116.697 | 90% | 10% | 1005.027 | 111.670 |
| **2007** | 1492.517 | 90% | 10% | 1343.265 | 149.252 |
| **2008** | 1536.659 | 90% | 10% | 1382.993 | 153.666 |

| | Amount of bitumen mixtures used (kt) | % of asphalt used for Road Paving | % of asphalt used for Asphalt roofing | Road Paving with asphalt (kt) | Asphalt roofing (kt) |
|---|---|---|---|---|---|
| **2009** | 838.446 | 90% | 10% | 754.602 | 83.845 |
| **2010** | 937.177 | 90% | 10% | 843.459 | 93.718 |
| **2011** | 1481.480 | 90% | 10% | 1333.332 | 148.148 |
| **2012** | 1584.974 | 90% | 10% | 1426.476 | 158.497 |
| **2013** | 1255.138 | 90% | 10% | 1129.624 | 125.514 |
| **2014** | 1289.971 | 90% | 10% | 1160.974 | 128.997 |

According to CSB data the biggest share of NMVOC and $CO_2$ emissions are originating during road paving with asphalt. Just small part of all bitumen mixtures is used in asphalt roofing sector (Table 4.32).

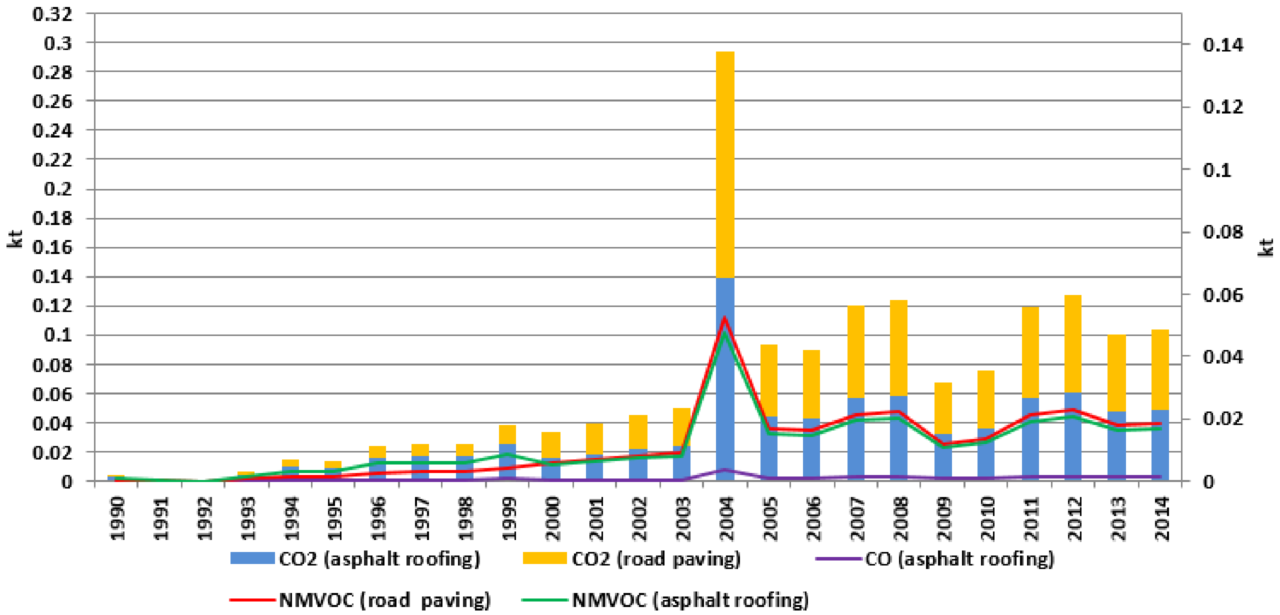


**Figure 4.13 Emissions from asphalt roofing and road paving in 1990–2014 (kt)[51]**

The emissions from these two particular sectors are constantly increasing since the beginning of 1990s. Slight emission decrease in 1999-2000 could be explained with the change of percentage that is used to divide activity data used in roofing and road paving. The sharp emission increase in 2003-2004 could be explained with Latvia's accession to EU in the May of 2004 before and after when the road paving works were very active and there were built VIA Baltic that connects all Baltic States. In 2011 and 2012 there are raised activity for road paving and asphalt roofing about 58.08% and 6.99% respectively. In 2013 there is decreased overall activity of bitumen use in industrial processes about 20.81% and it

*[51]NMVOC emissions from road paving with asphalt,and asphalt roofing and CO emissions from asphalt roofing on secondary axis*

depends on financial resources that are assigned directly to this sector for road paving or asphalt roofing. In 2014 there are quite stable situation in this sector (Figure 4.13).

**Urea use**

Urea are used as catalyst in fuel consumption and calculated under 1.A.3 Transport sector but emissions are reported under 2.D Non- energy Products from Fuels and Solvent Use (Table 4.33).

**Table 4.33 Data from Urea use 2006-2014 (kt)**

| | Urea consumption | $CO_2$ emissions |
|---|---|---|
| **1990** | NO | NO |
| **1995** | NO | NO |
| **2000** | NO | NO |
| **2005** | NO | NO |
| **2006** | 2.006 | 0.133 |
| **2007** | 2.007 | 0.419 |
| **2008** | 2.008 | 0.497 |
| **2009** | 2.009 | 0.471 |
| **2010** | 2.01 | 0.563 |
| **2011** | 2.011 | 0.521 |
| **2012** | 2.012 | 0.528 |
| **2013** | 2.013 | 0.538 |
| **2014** | 3.427 | 0.817 |

### 4.5.3.2 Methodological issues

**Solvent Use**

The NMVOC inventory is carried out to fulfil the obligations of the United Nations Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution (UNECE CLRTAP).

NMVOC emissions from Solvent Use sector (except 2D3f and partly 2D3g) were calculated according to EMEP/EEA 2013 methodology based on Tier 1 or Tier 2 approach and used particular emission factors for several source sub-categories (see Table 4.34).

**Table 4.34 Approaches and emission factors for Solvent Use sector**

| Subcategories | NRF | EF | Tier | Unit |
|---|---|---|---|---|
| Cosmetics and toiletries (all) | 2D3a | 0.83 | 2 | t/t solvent |
| Household products (all) | 2D3a | 0.65 | 2 | t/t solvent |
| DIY/buildings (all), Adhesives, Paint/varnish removers and solvents | 2D3a | 0.95 | 2 | t/t solvent |
| Car care products (all) | 2D3a | 0.94 | 2 | t/t solvent |
| Pesticides | 2D3a | 0.865 | 2 | t/t solvent |
| Domestic use of pharmaceutical products | 2D3a | 0.606 | 2 | t/t product |
| Paint application: construction and buildings | 2D3d | 0.15 | 1 | t/t paint applied |
| Paint application: domestic use | 2D3d | 0.15 | 1 | t/t paint applied |
| Coating applications: manufacture of automobiles | 2D3d | 0.4 | 1 | t/t paint applied |
| Paint application: car repairing | 2D3d | 0.4 | 1 | t/t paint applied |

| Subcategories | NRF | EF | Tier | Unit |
|---|---|---|---|---|
| Paint application: coil coating | 2D3d | 0.4 | 1 | t/t paint applied |
| Coating applications: Boat building | 2D3d | 0.4 | 1 | t/t paint applied |
| Paint application: wood | 2D3d | 0.4 | 1 | t/t paint applied |
| Coating applications: Other industrial paint application | 2D3d | 0.2 | 1 | t/t paint applied |
| Other non industrial paint application | 2D3d | 0.2 | 1 | t/t paint applied |
| Degreasing | 2D3e | 0.46 | 1 | t/t cleaning products |
| Chemical products, manufacture and processing | 2D3g | 0.01 | 1 | t/t product |
| Polystyrene foam processing | 2D3g | 0.06 | 2 | t/t polystyrene |
| Rubber processing | 2D3g | 0.008 | 2 | t/t rubber produced |
| Tyre production | 2D3g | 0.01 | 2 | t/t tyres |
| Paints manufacturing | 2D3g | 0.011 | 2 | t/t product |
| Glass Wool Enduction | 2D3g | 0.25 | 2 | t/t solvent |
| Pharmaceutical products manufacturing | 2D3g | 0.3 | 2 | t/t solvent |
| Printing | 2D3h | 0.5 | 1 | t/t ink |
| Fat, edible and non-edible oil extraction | 2D3i | 0.002 | 1 | t/t product used |
| Application of glues and adhesives | 2D3i | | | |
| Preservation of wood | 2D3i | 0.945 | 2 | t/t preservative (organic solvent-borne preservative) |
| Preservation of wood | 2D3i | 0.005 | 2 | t/t preservative (waterborne preservative) |
| Other solvent and product use | 2D3i | 0.002 | 2 | t/t product |

From the 1990s till 2005 statistics for Solvent Use was not well kept due to the country-wide changes in the governmental system and national economy. For 2006-2014 activity data for Paint application, Degreasing, Chemical Products (partly), Printing industry, Domestic solvent use and Other solvent use was obtained from the Register of Chemical Substances and Chemical Mixtures (CR) at Ltd. Latvian Environment, Geology and Meteorology Centre. In the CR data of imported and produced amount of chemical products containing NMVOCs is collected together with the percentage of a particular NMVOC in imported or produced products. It is assumed that the NMVOC containing products imported in the country in a particular year are utilized in the same year as the data of the actual use is not available or is confidential. In the CR information on a particular year, amount of produced and imported chemicals (ton), NACE code, trade name, chemical name, CAS number and concentration (from … till %) is provided.

NMVOC emissions (kt) from Solvent Use sector (except 2D3f and partly 2D3g) were calculated for the time series 2006-2014 using the equation below.

$$E_{NMVOC} = EF_{NMVOC} \times AD$$

*where:*
$E_{NMVOC}$ *– non-methane volatile organic compounds emissions from solvents and other production use (kt)*
$EF_{NMVOC}$ *– emission factor from EMEP/EEA 2013*
*AD – activity data from the Chemical Register (kt)*

To obtain a comparable data in time series for years where statistics was not well kept NMVOC emissions were calculated using the same methodology as for years 2006-2014. Assuming that base year for NMVOC emissions is year 2006, NMVOC emissions for years where statistics was not well kept were calculated proportionally, taking into account the number of inhabitants taken from CSB database.

NMVOC emissions data from Dry cleaning and Chemical products subsectors is obtained directly from database "2-Air" at Ltd. Latvian Environment, Geology and Meteorology Centre for 2006-2014. From the 1990s till 2005 statistics for NMVOC emissions data also was not well kept. "2-Air" is database where enterprises (that do any pollution activity and have category A, B, or C polluting activity) report their emissions data; it is approximately 3000 enterprises in total every year. From these approximately 3000 enterprises data is used only from the enterprises that produced NMVOC emissions according to EMEP/EEA 2013. The enterprises have been reporting their produced NMVOC emissions dividing in a particular NMVOC.

Activity data from Dry cleaning and Chemical products subsectors reported by enterprises is not available as these data is not required to be reported and could be assumed as confidential.

Indirect $CO_2$ emissions from Solvent Use sector was estimated using methodology from the 2006 IPCC Guidelines:

$$Emissions_{CO2} = Emissions_{NMVOC} \cdot Percent\ carbon\ in\ NMVOCs\ by\ mass \cdot 44.0098/12.011$$

It was assumed that the average carbon content of NMVOC is 60% by mass for all categories under the sector of Solvent Use in accordance with the 2006 IPCC Guidelines.

This leads to an emission factor for indirect $CO_2$ release of 2.198474731 kg $CO_2$/kg NMVOC.

**Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)**

EMEP/EEA 2013 Tier1 was used to estimate NMVOC emissions from the 2.D.3.b Road paving with asphalt and 2.D.3.c Asphalt roofing. According to CSB data the biggest part of bitumen mixtures amount is used for road paving. Only small part is used for roofing activities (Table 4.35).

NMVOC emissions are estimated using simpler default methodology:

$$E_{NMVOC} = AD_{bitumen} \times EF_{NMVOC}$$

*where:*
*$E_{NMVOC}$ – NMVOC emissions (kt)*
*$AD_{bitumen}$ – bitumen and bitumen mixtures used in CRF 2.D.3.b and 2.D.3.c activities (kt)*
*$EF_{NMVOC}$ –NMVOC emission factor (kt/kt)*

Indirect $CO_2$ emissions from asphalt roofing and road paving with asphalt activities were estimated according to 2006 IPCC Guidelines and explanation of indirect $CO_2$ emission estimation basing on carbon conversion factor and average default carbon content amount.

For the $CO_2$ emission estimation NMVOC emissions were taken as activity data and $CO_2$ emissions were estimated using carbon conversion factor:

$$E_{CO_2} = EF_{CO_2} \times NMVOC$$

*where:*
*$E_{CO2}$ – $CO_2$ emissions (kt)*
*$EF_{CO2}$ – estimated $CO_2$ emission factor*
*NMVOC – NMVOC emissions (kt)*

*Emission factors*

For $CO_2$ emission estimation 80% of carbon content conversion factor are used. According to 2006 IPCC Guidelines [52] indirect emissions of $CO_2$ from atmospheric oxidation of emitted NMVOC are included in the national emission inventory. The average amount of carbon in NMVOC is assumed as 80%[53].

Therefore the $CO_2$ emission factor from 2006 IPCC Guidelines was estimated using following equation:

$$EF_{CO_2} = 80\% \times 44.0098/12.011$$

*where*
*$EF_{CO2}$ – $CO_2$ emission factor (kt/kt)*
*80% – the average amount of carbon in NMVOC*
*44.0098 / 12.011 – carbon dioxide and carbon molmass ratio*

This leads to an emission factor for indirect $CO_2$ release of 2.931299642 kg $CO_2$/kg NMVOC.

Default CO and NMVOC emission factors are taken from EMEP/EEA 2013.[54,55] Due to lack of the technology use information Tier1 EFs were used (Table 4.35).

**Table 4.35 Emission factors for asphalt roofing and Road paving in 1990–2014**

| | $CO_2$ (t $CO_2$/t NMVOC) | CO (kt/kt) | NMVOC (kt/kt) |
|---|---|---|---|
| **Asphalt Roofing** | 2.93 | 0.0000095 | 0.00013 |
| **Road Paving with Asphalt** | 2.93 | NE | 0.000016 |

**Urea use**

Description of methodology to calculate $CO_2$ emissions from Urea use is reported under sector 1.A.3 Transport.

#### 4.5.3.3 Uncertainties and time series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

**Solvent use**

*[52] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_7_Ch7_Precursors_Indirect.pdf (page 7.6)*
*[53] Basing of the most often used average carbon conversion factor*
*[54] http://www.eea.europa.eu/publications/emep-eea-guidebook-2013, 2.D.3.b Road paving with atsphalt pdf (page8)*
*[55] http://www.eea.europa.eu/publications/emep-eea-guidebook-2013 2.D.3.c Asphalt roofing pdf (page 9)*

Uncertainty of activity data for estimations of NMVOC emissions from Solvent Use is calculated as 16%. Time series consistency was ensured by using one method for all time series.

**Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)**

Uncertainty of activity data for estimations of $CO_2$ emissions from 2.D.3.c Asphalt roofing sector and 2.D.3.b Road paving with asphalt sector is assumed rather low as CSB data of used bitumen mixtures are used and the percentage of 2006 IPCC Guidelines is used to divide bitumen use for roofing and paving activities. Still as it is not clearly known how much of the total bitumen is used for asphalt paving and for asphalt roofing (bitumen use in construction sector) the uncertainty is assumed at least 20%.

The $CO_2$ emission factors for 2.D.3.b and 2.D.3.c sectors are assumed as high as 70% because default emission factors are used and $CO_2$ emissions are estimated from NMVOC emissions. The uncertainty of indirect emission factors for these two sectors taken from EMEP/EEA 2013 as Tier 1 EFs is assumed as high as 50% as the default emission factors are used.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. $NO_x$, CO and $SO_2$ emissions are not estimated due to lack of estimation methodology and official emission factors.

Time series consistency was checked by verifying IEF, AD and emission changes and attention was paid to important increase/decrease that are explained in NIR.

#### 4.5.3.4 Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

**Solvent use**

All estimations of the emissions done in the LEGMC are checked on the logical mistakes by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in the national legislation. All findings were documented and introduced in GHG inventory. All corrections are archived in centralized archiving system (common FTP folder).

**Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)**.

Activity data used in NMVOC and $CO_2$ emissions from asphalt roofing and road paving with asphalt was reported by CSB in Annual Questionnaire tables. Bitumen data used in emission estimation and reported in NIR are verified by CSB. Data also is compared to the data reported in 1A(d) sector.

CSB has the internal QA/QC procedures based on mathematical model and analysis to avoid logic mistakes.

The activity data used in estimations is repeatedly verified by CSB energy experts by checking the data input in data estimation database and reported in the NIR.

All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogic changes in the activity data and emissions.

The QC form has been filled in for each category taking into account criteria given in QA/QC plan approved in national legislation. Form then is archived.

#### 4.5.3.5 Source-specific recalculations

**Solvent use**

For period 1990-2014 recalculations have been carried out under Solvent Use sector mainly due to two reasons. The first one is that the list of NMVOCs substances was corrected, therefore recalculations were carried out for all time series. The second reason is change of method according to EMEP/EEA 2013 for all time series (see Chapter 4.5.3.2.).

**Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)**

No recalculations were done in this sector.

#### 4.5.3.6 Source-specific improvements

**Solvent use**

It is planned to implement electronic reporting for importers and producers in the Chemicals Register from 2016. According to that, possible changes in activity data are expected. It is planned to get more accurate division by subcategories taking into account that previously it was done by expert judgment.

**Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)**

No improvements are planned for this sector.

## *4.6 ELECTRONICS INDUSTRY (CRF 2.E)*

HFC, PFC, $SF_6$ and $NF_3$ emissions from manufacturing of integrated circuit of semiconductors, TFT flat panel displays, photovoltaics and heat transfer fluids are not occurring in Latvia.

There is one company in Latvia which manufactures liquid crystal displays (LCDs) and 3D products for industrial, professional, medical and defence applications. Directly contacting with the company they confirmed that $NF_3$ is not used in technology as well as company has no plans to use it in the future.

Other types of equipment listed in 2006 IPCC Guidelines, Volume 3, Chapter 6 under this sector are not being manufactured in Latvia. Currently using CRF Reporter software version 5.14 it is not possible to enter NO in green and grey cells although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

Under Electronics industry subcategories Latvia doesn`t report emissions so child nodes (gases) are not added according to CRF User manual however it is not currently possible to enter data in green cells so some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank.

## 4.7 PRODUCT USES AS SUBSTITUTES FOR OZONE DEPLETING SUBSTANCES (ODS) (CRF 2.F)

Under 2.F Latvia reports emissions from usage of hydrofluorocarbons (HFCs) occurring in following sectors:

- Refrigeration and air-conditioning equipment (CRF 2.F.1);
- Foam blowing products (CRF 2.F.2);
- Fire Protection (CRF 2.F.3);
- Aerosols (CRF 2.F.4).

In 2014 GHG emissions from Product uses as substitutes for ODS substances amounted 212.06 kt $CO_2$ eq (1.9%) from total $CO_2$ equivalent emissions without LULUCF. Compared to 2013 F-gases emissions have increased by 3.8%, but compared to 1995 emissions have increased by 1744%.

There is no production of HFCs in Latvia. Emissions of the perfluorocarbons (PFCs) and nitrogern trifluoride ($NF_3$) do not occur in Latvia for all time series. HFC and PFC emissions from Solvents (CRF 2.F.5) and Other Applications (CRF 2.F.6) are not occurring in Latvia (reported as "NO" in CRF Reporter). Currently using CRF Reporter software version 5.14 it is not possible to enter NO in green and grey cells therefore some information in the parent category (green cells) in corresponding CRF tables are missing.

The calculation of emissions under 2.F was carried out for following gases:

- HFC–23
- HFC–32
- HFC–125
- HFC–134a
- HFC–143a
- HFC–152a
- HFC-245fa
- HFC-365mfc
- HFC–227ea

The major part of 2F emissions constitutes 2.F.1 Refrigeration and Air Conditioning (97.3%) which is also a key category by of Latvia`s GHG inventory. Additionally 2.2% from 2F emissions comes from 2.F.4. Aerosols (metered dose inhalers), but less than 1% comes from 2.F.2 Foam blowing agents (0.5%) and 2.F.3 Fire protection in 2014 (0.01%) (Figure 4.14).

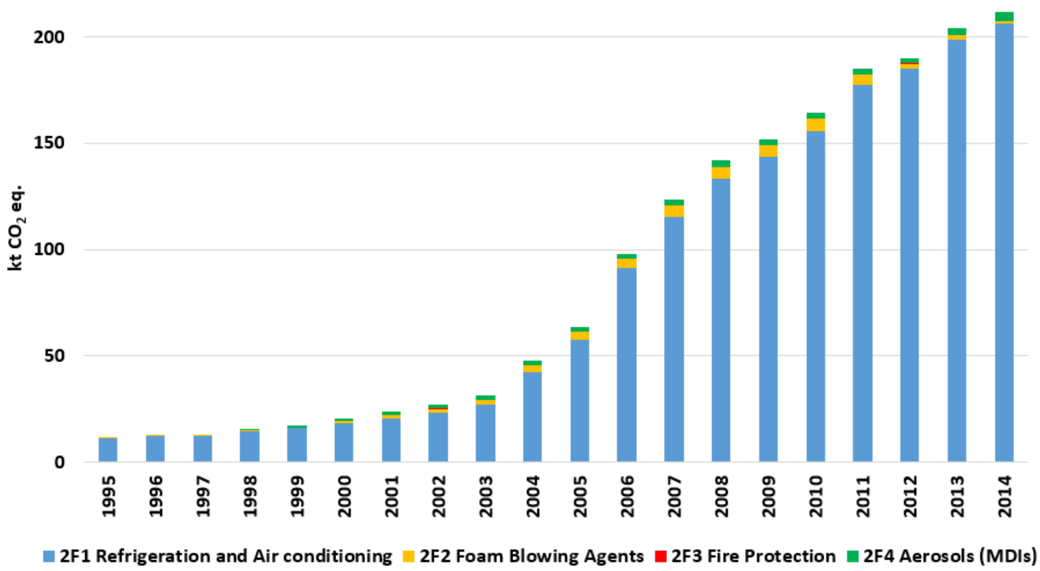


**Figure 4.14 HFC emissions from 2.F Product Uses as ODS Substitutes (kt $CO_2$ eq.)**

The total emissions from 2.F have increased significantly since 1995 (see Table 4.36 and Figure 4.14). The main reason which caused emission growth was substitution of ODS with nature friendlier alternatives commonly named F-gases in refrigeration and air conditioning appliances. The usage of products which substitute ODSs in Latvia mainly depends on import. The imported amounts could be associated with economic situation in the country consequently this led to F-gases emission growth. As the significant part of total F-gases emissions (32.3% in 2014) results from use of mobile air conditioning systems in road transport, the emission growth is also a result of increase of car population under this sector.

**Table 4.36 HFC emissions from 2.F Product Uses as Substitutes for ODS, 1995-2014 (kt $CO_2$ eq.)**

| Year | 2.F | 2.F.1 | 2.F.2 | 2.F.3 | 2.F.4 |
|---|---|---|---|---|---|
| | Product Uses as Substitutes for ODS | Refrigeration and Air Conditioning | Foam blowing agents/ foaming of polyether (for shoe soles) | Fire Protection | Aerosols (Metered dose inhalers) |
| **1995** | 11.50 | 11.10 | 0.40 | NO,NE | NO,NE |
| **2000** | 20.46 | 18.44 | 0.78 | NO,NE | 1.24 |
| **2001** | 23.92 | 20.66 | 1.52 | 0.02 | 1.73 |
| **2002** | 27.20 | 23.18 | 1.97 | 0.02 | 2.03 |
| **2003** | 31.18 | 26.84 | 2.38 | 0.04 | 1.93 |
| **2004** | 47.54 | 42.34 | 3.21 | 0.08 | 1.91 |
| **2005** | 63.48 | 57.66 | 3.64 | 0.05 | 2.13 |
| **2006** | 98.09 | 91.46 | 4.22 | 0.02 | 2.39 |
| **2007** | 123.59 | 115.63 | 5.18 | 0.01 | 2.77 |
| **2008** | 142.02 | 133.19 | 5.81 | 0.01 | 3.00 |
| **2009** | 152.14 | 143.90 | 5.41 | 0.01 | 2.82 |
| **2010** | 164.42 | 155.49 | 6.19 | 0.02 | 2.72 |
| **2011** | 184.97 | 177.73 | 4.51 | 0.02 | 2.71 |
| **2012** | 190.21 | 184.97 | 2.63 | 0.06 | 2.55 |

| Year | 2.F | 2.F.1 | 2.F.2 | 2.F.3 | 2.F.4 |
|---|---|---|---|---|---|
| | **Product Uses as Substitutes for ODS** | **Refrigeration and Air Conditioning** | **Foam blowing agents/ foaming of polyether (for shoe soles)** | **Fire Protection** | **Aerosols (Metered dose inhalers)** |
| **2013** | 204.35 | 198.93 | 1.84 | 0.06 | 3.52 |
| **2014** | 212.06 | 206.38 | 0.96 | 0.03 | 4.70 |
| **Share of total IPPU emissions in 2014 (%)** | 25.3% | 24.7% | 0.1% | 0.003% | 0.6% |
| **2014 versus 2013** | +3.8% | +3.7% | -47.7% | -55.4% | +33.4% |
| **2014 versus 1995** | +1744% | +1759.0% | +140.2% | +76.5%[56] | +2637%[57] |

In 2004 the first investigation of F-gases sources and emissions in Latvia was carried out. Within the project "$SF_6$, HFC and PFC emission inventory in Latvia 1995-2003" [58] (hereinafter F-gases research (2004)) the areas and users of F-gases in Latvia were identified for the first time. The result of this project was initial activity and consumption data for F-gases emission estimation (in accordance with IPCC 1996 methodology). Activity data and assumptions derived during this project and shortly after were used for F-gases emission calculations.

In 2015 and 2016 the F-gases research within the EEA Financial Mechanism 2009-2014 Programme "National Climate Policy (hereinafter F-gases research (2016)) was carried out. The aim of this research was to improve activity data obtaining process and emission factors in 2.F.1 Refrigeration and Air conditioning sector as well as to split the activity data for years 2004-2014 between the 2.F.1 subcategories according to 2006 IPCC Gudelines.

The research has been bottom-up orientated. F-gases importers, suppliers, users and service companies were asked to supplement the information reported under EU Regulation (EU) No 517/2014[59] and national Regulations No.563[60] with the information regarding the sector and purpose of the substances they import, use or refill in equipment in the country. Data base containing information regarding amounts of ODS and F-gases imported, refilled and held in stocks is maintained by LEGMC according to previous mentioned regulations. As a result data from the particular database was divided by categories relevant to 2006 IPCC Gudelines 2.F.1 sector subcategories. Emission factors and assumptions were discussed and confirmed by Latvian Freezing Equipment Engineers` Association which is the responsible institution in certification of F-gases operators in Latvia.

[56] *2014 versus 2001 as time series for Fire Protection started in 2001*
[57] *2014 versus 1998 as time series for Aerosols started in 1998*
[58] *Project report "$SF_6$, HFC and PFC emission inventory in Latvia 1995-2003", Riga 2004*
[59] *EU Regulation (EU) No 517/2014 of The European Parliament and the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006*
[60] *Regulation No.563 of the Cabinet of Ministers of Latvia on special restrictions and prohibitions regarding activities with ozone-depleting substances and fluorinated greenhouse gases*

## 4.7.1 Refrigeration and Air Conditioning (CRF 2.F.1)

### 4.7.1.1 Category description

The calculation of actual emissions from Refrigeration and Air Conditioning is done according to the 2006 IPCC Guidelines, Chapter 7 (Emissions of Fluorinated Substitutes for Ozone Depleting Substances) and Chapter 8 (Other Product Manufacture and Use).

Refrigeration and Air Conditioning Systems are responsible for about 93.5% of the Latvia`s F-gas emissions in 2014. Under 2.F. sector HFC emissions are reported covering 6 subcategories according to 2006 IPCC Gudelines:

- Commercial Refrigeration (refrigerators for supermarkets, shops etc.);
- Domestic Refrigeration (fridges and freezers in households);
- Industrial Refrigeration (refrigeration units in food and chemical industries);
- Transport Refrigeration (refrigerated vehicles);
- Mobile Air Conditioning (air conditioning systems in passenger cars, trucks and buses);
- Stationary Air Conditioning (room air-conditioning systems and heat pumps).

In 2014 HFC emissions from 2.F.1 Refrigeration and Air Conditioning totalled 206.38 kt $CO_2$ equivalent. Compared to 2013 the emissions were increased by 3.7%. In 2014 the mayority of F-gases emissions under 2.F.1 originates from 2.F.1.a Commercial Refrigeration (41.2%) 2.F.1.e Mobile air conditioning (34.6%), and 2.F.1.c Industrial Refrigeration (11.5%)  Other less significant sources are 2.F.1.f Stationary Air Conditioning (9.7%), 2.F.1.d Transport Refrigeration (2.8%) and 2.F.1.b Domestic Refrigeration (0.2%) (Figure 4.15).

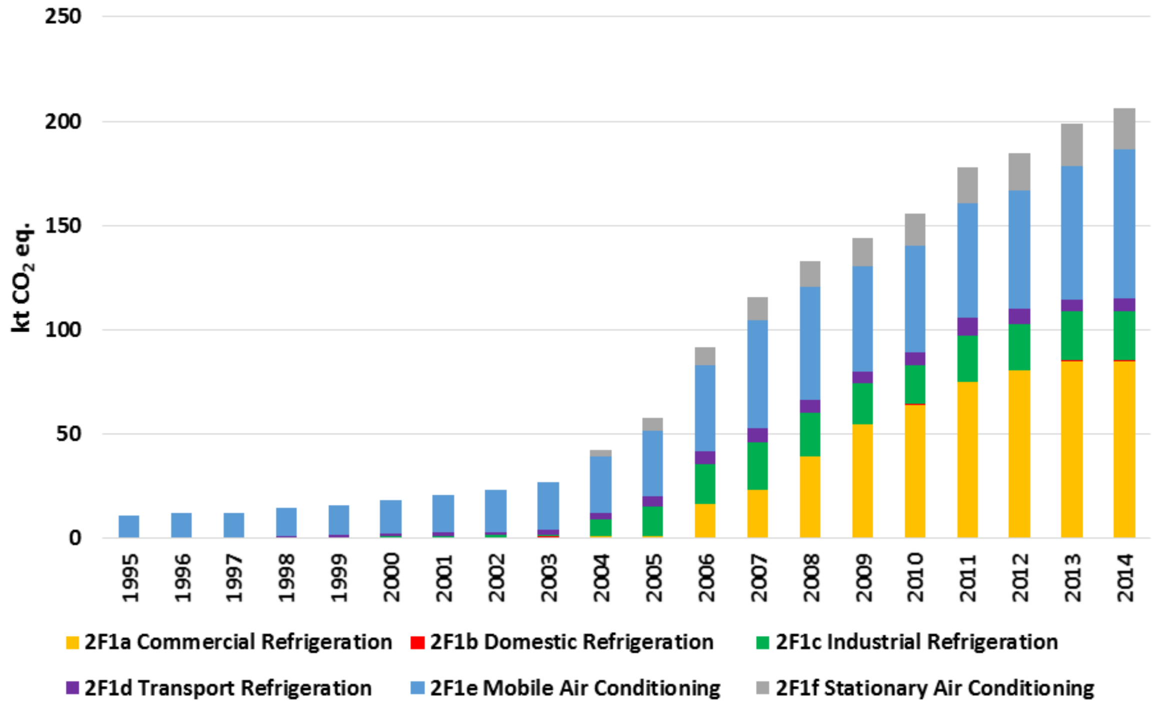


**Figure 4.15 F-gases emissions from 2.F.1. Refrigeration and Air Conditioning equipment (kt $CO_2$ eq.)**

### 4.7.1.2 Methodological issues

An overview of the methods used and gases reported under 2.F.1 sector is presented in Table 4.37.

**Table 4.37 Summary of emission calculation methods and gases in CFR 2.F.1**

| CRF Category/subcategory | Method used | Gases reported |
|---|---|---|
| 2.F.1 Refrigeration and Air Conditioning | | |
| *2.F.1.a Commercial Refrigeration* | Tier 2a | HFC-134a<br>HFC-32<br>HFC-125<br>HFC-143a<br>HFC-152a<br>HFC-23 |
| *2.F.1.b Domestic Refrigeration* | Tier 2a | HFC-134a |
| *2.F.1.c Industrial Refrigeration* | Tier 2a | HFC-134a<br>HFC-32<br>HFC-125<br>HFC-143a |
| *2.F.1.d Transport Refrigeration* | Tier 2a | HFC-134a<br>HFC-32<br>HFC-125<br>HFC-143a<br>HFC-23 |
| *2.F.1.e Mobile Air Conditioning* | Tier 2a | HFC-134a |
| *2.F.1.f Stationary Air Conditioning* | Tier 2a | HFC-134a<br>HFC-32<br>HFC-125<br>HFC-143a |

- *Commercial Refrigeration (CRF 2.F.1.a)*

*Activity data*

Activity data for emission calculation is taken from annual reports by F-gases operators according to Regulation (EC) No. 517/2014 and national legislation No.563[61] "Regulations of ozone depleting substances and fluorinated greenhouse gases that are freezing agents". According to these regulations operators (merchants and other institutions) which perform activities with ozone depleting substances or F-gases annually shall report to LEGMC the following information:

- Name of the substance;
- Amount of substance at the beginning of the year;
- Imported amount;
- Exported amount;
- Charged amount in freezing equipment units;
- Recycled amount;
- Regenerated amount;

[61] *http://likumi.lv/ta/id/233736-noteikumi-par-ipasiem-ierobezojumiem-un-aizliegumiem-attieciba-uz-darbibam-ar-ozona-slani-noardosam-vielam-un-fluoretam-siltumn...*

- Disposed amount;
- Amount of substance at the end of the year.

245 operators reported data of their activities with F-gases in 2014. For historical years activity data were obtained from questionnaires within previous F-gases research. For 2004-2005 activity data were obtained from enterprises that responded on data request letters sent by LEGMC. For 2006-2014 data were obtained from reporting within previously mentioned regulation act or extrapolated.

*Emission factors and calculations*

Tier 2a – emission-factor approach from 2006 IPCC Guidelines was used to estimate emissions from commercial refrigeration. Emissions result from charging, lifetime and end-of-life of equipment and are calculated for each type of HFC separately.

According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. These emissions come from:

- $E_{charge,\ t}$ – emissions related to the refrigerant charge: connection and disconnection of the refrigerant container and the new equipment to be charged;
- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,}t$ – emissions at system disposal.

Equation 7.10 from 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$E_{total,t} = E_{Charge,t} + E_{Lifetime,t} + E_{End\text{-}of\text{-}life,t}$$

There are no HFC-containing equipment manufacturing companies in Latvia and all appliances used in commercial refrigeration are imported.

Emission factors and assumptions used in emission calculation from commercial refrigeration are as follows:

- HFCs mainly charged in Commercial Refrigeration are HFC-134a, HFC-404a, HFC-422d, HFC-407c, HFC-507a and HFC-410a;
- Average emission factor during charging of equipment is 1.8%[62];
- Average emission factor during operation of equipment is 18%[63];
- Average life time of commercial applications assumed 15 years;
- Residual charge of HFC in equipment being disposed 80%[64];
- Recovery efficiency at disposal 70%[65].

Equation from 2006 IPCC Guidelines for charging emissions estimation:

$$E_{Charged,\ t} = M_t \times k/100$$

*[62] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for commercial applications.*
*[63] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for commercial applications.*
*[64] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9*
*[65] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9*

*where:*
*$E_{charged}$ – emissions during system manufacture/assembly in year (kg)*
*Mt – amount of HFC charged into a new equipment in year (kg)*
*k – charging losses (%)*

Equation from 2006 IPCC Guidelines for emission estimation stocks:

$$E_{lifetime,\ t} = B_t \times x / 100$$

*where:*
*$E_{lifetime}$ – amount of emissions during equipment operation (t)*
*Bt – amount of HFC held in stocks in year t*
*x – losses during operation period (%)*

Equation from 2006 IPCC Guidelines for emission estimation from disposal:

$$E_{end\text{-}of\text{-}life,\ t} = M_{t\text{-}d} \times p/100 \times 1\text{-}(\eta_{rec,\ d} / 100)$$

*where:*
*$E_{lend\text{-}of\text{-}life}$– amount of HFC emitted at system disposal in year (t)*
*Mt-d – residual charge of HFC in equipment being disposed of expressed in percentage of full charge (%)*
*ηrec, d – recovery efficiency at disposal, which is the ration of recovered HFC reffered to the HFC contained in the system (%)*

The total amount of HFC charged into commercial refrigeration equipment in 2014 amounts to 23.45 t constituting 0.41 t manufacturing emissions. HFC in stocks amounts to 129.91 t constituting 23.38 t operating emissions. As the HFC amounts filled into refrigeration equipment are available since 1998, the decommissioning emissions according to 15 years lifetime could be estimated starting from 2013. The amount of HFCs remained in decommission is amount of refrigerant initially charged into the systems in 1999 (0.19 t) which constitutes 0.05 t disposal emissions in 2014.

- <u>*Domestic Refrigeration (CRF 2.F.1.b)*</u>

*Activity data*

This category includes all refrigeration units (fridges and freezers) for domestic use. As there is no production of such equipment in Latvia, emissions could be estimated taking into account data on imported units which are charged and used within the country. Prior to 1990 most refrigeration appliances used CFC-12. Since 1993 there was a shift to HFC-134a. Many countries have subsequently moved to systems using hydrocarbon HC-600a which is now the predominant refrigerant for new domestic refrigeration appliances.

HFC emissions in domestic refrigeration are estimated from HFC-134a.

The activity data for HFC-134a emission estimation from domestic refrigerators and freezers are:

- number of inhabitants in Latvia – data taken from CSB database „Resident population at the beginning of the year”[66];

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[66]*http://data.csb.gov.lv/pxweb/en/Sociala/Sociala__ikgad__iedz__iedzskaits/IS0020.px/table/tableViewLayout1/?rxid=a79839fe-11ba-4ecd-8cc3-4035692c5fc8*

- number of households in Latvia – data taken from CSB database „Total number of households and the average size of a household"[67];
- number of new imported fridges and freezers – data taken from CSB database "Imports by countries 1995-2014"[68];
- share of annually sold new equipment filled with HFC-134a – taken from Finland according to Finnish research[69];
- percentage of households using refrigerators and freezers – for 1996, 2001, 2006 and 2010 years data taken from CSB database „Number of electrical appliances used in dwellings and average age of appliances" [70];
- percentage of refrigerators and freezers charged with HFC-134a from 1995 till 2005 were determined during first F-gases research in 2004. As from 2006 the F-gases regulation entered into force it was assumed that the share of HFC-134a containing domestic refrigerators (stocks) started to decrease since that time. All European manufacturers of household appliances have changed their production from HFC-134a to R600a some time ago and appliances containing HFC-134a have only been imported from outside the EU to a small extent in recent years. No new equipment entered the stock from 2011 onwards. It was confirmed by Latvian Freezing Equipment Engineers` Association that the share of HCF-134a in domestic refrigeration stock is 15%.

*Emission factors and calculations*

HFC-134a emissions from domestic refrigerators and freezers are estimated by using 2006 IPCC Guidelines Guidelines Tier 2a – Emission-factor approach.

Emission factors and assumptions used in emission calculation from domestic refrigeration are as follows:

- Country specific average refrigerant charge per unit: 150 g HFC-134a;
- Default manufacturing emission factor 0.6%[71];
- Default operating emission factor 0.3%[72];
- Default disposal emission factor 80%[73];
- Recovery efficiency at disposal 70%[74].

There are no manufacturing companies in Latvia and all domestic refrigerators and freezers are imported.

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[67] *http://data.csb.gov.lv/pxweb/en/Sociala/Sociala__ikgad__iedz__iedzskaits/IS0210.px/?rxid=562c2205-ba57-4130-b63a-6991f49ab6fe*
[68] *http://data.csb.gov.lv/pxweb/en/atirdz/atirdz__detalizeta__8zim/?tablelist=true&rxid=cdcb978c-22b0-416a-aacc-aa650d3e2ce0*
[69] *http://www.vtt.fi/inf/pdf/tiedotteet/2001/T2099.pdf*
[70] *http://data.csb.gov.lv/pxweb/en/vide/vide__energ_pat/0201.px/table/tableViewLayout1/?rxid=a79839fe-11ba-4ecd-8cc3-4035692c5fc8*
[71] *2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9, average value applied for domestic refrigeration*
[72] *2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9, average value applied for domestic refrigeration*
[73] *2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9, value applied for domestic refrigeration*
[74] *2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9*

That gives approximate annual amount of HFC-134a charged that is estimated with equation from 2006 IPCC Guidelines:

$$HFC_{Charged,t} = R \times n/f$$

*where:*
*$HFC_{charged}$ – amount of HFC-134a charged in year t (tonnes)*
*R – amount of refrigerators and freezers charged with HFC-134a (units)*
*n – average equipment lifetime (years)*
*f – amount of HFC-134a charged once in lifetime of equipment*

Equation from 2006 IPCC Guidelines was used for charging emissions estimation:

$$E_{Charged,t} = Mt \times k/100$$

*where:*
*$E_{charged}$ – emissions during system manufacture/assembly in year (kg)*
*Mt – amount of HFC-134a charged into a new equipment in year (kg)*
*k – charging losses (%)*

Amount of HFC-134a in stocks is estimated according to data from CSB. Approximate amount of HFC-134a stored in domestic refrigerators and freezers was estimated based on CSB data on number of households and percentage of households using refrigerators and freezers as well as assumption of share (percentage) of refrigerators and freezers filled with with HFC-134a.

Equation from 2006 IPCC Guidelines for emissions estimation from equipment lifetime:

$$E_{lifetime,t} = B_t \times x/100$$

*where:*
*$E_{lifetime}$ – amount of HFC emitted during system operation in year (kg)*
*Bt – amount of HFC banked in existing systems in year (kg)*
*x – annual emission rate (%)*

According to 15 years lifetime it is assumed that first disposal emissions from domestic refrigerators and freezers appear in 2010. Equation from 2006 IPCC Guidelines for emission estimation from disposal:

$$E_{end\text{-}of\text{-}life,\,t} = M_{t\text{-}d} \times p/100 \times 1\text{-}(\eta_{rec,\,d} / 100)$$

*where:*
*$E_{lend\text{-}of\text{-}life}$– amount of HFC emitted at system disposal in year t (kg)*
*Mt-d – residusl charge of HFC in equipment being disposed of expressed in percentage of full charge, (%)*
*ηrec, d – recovery efficiency at disposal, which is the ration of recovered HFC reffered to the HFC contained in the system (%)*

In 2014 the total HFC emissions from HFC-134a used in domestic refrigeration amounts to 0.34 t or 0.49 kt $CO_2$ equivalent. The majority of HFC emissions from domestic refrigerators occur at end-of-life from 2010 onwords. Charging and stock emission rates are comparably low.

- *Industrial Refrigeration (CRF 2.F.1.c)*

*Activity data*

Activity data for emission calculation from Industrial Refrigeration is taken from annual reports by F-gases operators according to Regulation (EC) No. 517/2014 and national legislation No.563[75]. 245 operators reported data of their activities with F-gases in 2014. For historical years activity data were obtained from questionnaires within previous F-gases research. For 2004-2005 activity data were obtained from enterprises that responded on data request letters sent by LEGMC. For 2006-2014 data were obtained from reporting within previously mentioned regulation act or extrapolated.

*Emission factors and calculations*

Tier 2a – emission-factor approach from 2006 IPCC Guidelines was used to estimate emissions from industrial refrigeration. Emissions result from charging, lifetime and end-of-life of equipment and are calculated for each type of HFC separately.

According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. These emissions come from:

- $E_{charge,\ t}$ – emissions related to the refrigerant charge: connection and disconnection of the refrigerant container and the new equipment to be charged;
- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,}t$ – emissions at system disposal.

Equation 7.10 from 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$E_{total,t} = E_{Charge,t} + E_{Lifetime,t} + E_{End\text{-}of\text{-}life,t}$$

There are no HFC-containing equipment manufacturing companies in Latvia and all appliances used in industrial refrigeration are imported.

Emission factors and assumptions used in emission calculation from industrial refrigeration are as follows:

- HFCs mainly charged in Industrial Refrigeration are HFC-134a, HFC-404a, HFC-422d, HFC-407c, HFC-507a and HFC-410a;
- Average emission factor during charging of equipment is 1.8%[76];
- Average emission factor during operation of equipment is 16%[77];
- Average life time of industrial applications 15 years[78];
- Residual charge of HFC in equipment being disposed 80%[79];

[75] *http://likumi.lv/ta/id/233736-noteikumi-par-ipasiem-ierobezojumiem-un-aizliegumiem-attieciba-uz-darbibam-ar-ozona-slani-noardosam-vielam-un-fluoretam-siltumn...*
[76] *2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for industrial applications.*
[77] *2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for industrial applications.*
[78] *Assumed in accordance with similarities to Estonia and Lithuania*
[79] *2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9*

- Recovery efficiency at disposal 90%[80].

Equation from 2006 IPCC Guidelines for charging emissions estimation:

$$E_{Charged,\,t} = M_t \times k/100$$

*where:*
*$E_{charged}$ – emissions during system manufacture/assembly in year (kg)*
*Mt – amount of HFC-134a charged into a new equipment in year (kg)*
*k – charging losses (%)*

Equation from 2006 IPCC Guidelines for emission estimation stocks:

$$E_{lifetime,\,t} = B_t \times x\,/\,100$$

*where:*
*$E_{lifetime}$ – amount of emissions during equipment operation (t)*
*Bt – amount of F-gases held in stocks in year t (tonnes)*
*x – losses during operation period (%)*

Equation from 2006 IPCC Guidelines for emission estimation from disposal:

$$E_{end\text{-}of\text{-}life,\,t} = M_{t\text{-}d} \times p/100 \times 1\text{-}(\eta_{rec,\,d}\,/\,100)$$

*where:*
*$E_{lend\text{-}of\text{-}life}$– amount of HFC emitted at system disposal in year t (kg)*
*Mt-d – residusl charge of HFC in equipment being disposed of expressed in percentage of full charge, (%)*
*ηrec, d – recovery efficiency at disposal, which is the ration of recovered HFC reffered to the HFC contained in the system (%)*

The total amount of HFC filled into industrial refrigeration equipment in 2014 amounts to 7.07 t constituting 0.12 t manufacturing emissions. HFC in stocks amounts to 41.06 t constituting 6.57 t operating emissions. As the HFC amounts filled into refrigeration equipment are available since 1998, the decommissioning emissions according to 15 years lifetime could be estimated starting from 2013. The amount of HFCs remained in decommission is amount of refrigerant initially charged into the systems in 1999 (1.02 t) which constitutes 0.08 t disposal emissions in 2014.

- *Transport Refrigeration (CRF 2.F.1.d)*

*Activity data*

According to F-gases research (2004), only negligible amount of HFCs was used in railways and water transport. Small amount of HFC-23 was filled into refrigerating equipment in ships. HFC-134a and HFC-125 was filled into mobile refrigerators used in road transport. For 1995-2004 activity data for emission calculation were taken from responses to questionnaires during first F-gases research (2004).

For 2004-2005 activity data were obtained from enterprises that responded on data request letters sent by LEGMC. For 2006-2014 activity data for emission calculation from Transport Refrigeration is taken from annual reports by F-gases operators according to Regulation (EC) No. 517/2014 and national legislation No.563. 245 operators reported data of their activities

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[80] *2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9*

with F-gases in 2014. Share of substances used in transport refrigeration was obtained according to information provided by transport refrigeration companies.

*Emission factors and calculations*

Tier 2a – emission-factor approach from 2006 IPCC Guidelines was used to estimate emissions from transport refrigeration. Emissions result from charging, lifetime and end-of-life of equipment and are calculated for each type of HFC separately.

According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. These emissions come from:

- $E_{charge,\ t}$ – emissions related to the refrigerant charge: connection and disconnection of the refrigerant container and the new equipment to be charged;
- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,}t$ – emissions at system disposal.

Equation 7.10 from 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$E_{total,t} = E_{Charge,t} + E_{Lifetime,t} + E_{End\text{-}of\text{-}life,t}$$

There are no HFC-containing equipment manufacturing companies in Latvia and all appliances used in transport refrigeration are imported therefore HFC emissions are estimated from stocks and from disposal.

Emission factors and assumptions used in emission calculation from transport refrigeration are as follows:

- HFCs mainly charged in Transport Refrigeration are HFC-134a and HFC-404a;
- Average emission factor during charging of equipment is 0.6%[81];
- Country specific emission factor during operation of equipment is 30%[82];
- Average life time of transport applications 8 years[83];
- Residual charge of HFC in equipment being disposed 50%[84];
- Recovery efficiency at disposal 70%[85].

Equation from 2006 IPCC Guidelines for charging emissions estimation:

$$E_{Charged,\ t} = M_t \times k/100$$

*where:*
*$E_{charged}$ – emissions during system manufacture/assembly in year (kg)*
*Mt – amount of HFC-134a charged into a new equipment in year (kg)*
*k – charging losses (%)*

*[81] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for transport applications.*
*[82] Confirmed by Latvian Freezing Equipment Engineers` Association*
*[83] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for transport applications*
*[84] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9*
*[85] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9*

Equation from 2006 IPCC Guidelines for emission estimation stocks:

$$E_{lifetime,\,t} = B_t \times x / 100$$

*where:*
*$E_{lifetime}$ – amount of emissions during equipment operation (t)*
*Bt – amount of F-gases held in stocks in year t (tonnes)*
*x – losses during operation period (%)*

Equation from 2006 IPCC Guidelines for emission estimation from disposal:

$$E_{end\text{-}of\text{-}life,\,t} = M_{t\text{-}d} \times p/100 \times 1\text{-}(\eta_{rec,\,d} / 100)$$

*where:*
*$E_{lend\text{-}of\text{-}life}$– amount of HFC emitted at system disposal in year t (kg)*
*Mt-d – residusl charge of HFC in equipment being disposed of expressed in percentage of full charge, (%);*
*ηrec, d – recovery efficiency at disposal, which is the ration of recovered HFC reffered to the HFC contained in the system (%)*

The total amount of HFC filled into transport refrigeration equipment in 2014 amounts to 2.69 t constituting 0.02 t manufacturing emissions. HFC in stocks amounts to 7.51 t constituting 2.25 t operating emissions. As the HFC amounts filled into refrigeration equipment are available since 1998, the decommissioning emissions according to 8 years lifetime could be estimated 2006-2014. The amount of HFCs remained in decommission is amount of refrigerant initially charged into the systems in 2006 (3.24 t) which constitutes 0.16 t disposal emissions in 2014.

- *Mobile Air Conditioning (CRF 2.F.1.e)*

*Activity data*

Under 2.F.1.e HFC-134a emissions are estimated for the following road vehicle types which were assessed according to emission control system (EURO classes):

- Passenger cars
- Light Duty Vehicles <3,5t
- Heavy duty vehicles 3,5 -12 t
- Heavy duty vehicles >=12 t
- Buses <=18 t
- Buses >18 t

Average percentage of vehicles equipped with air conditioning systems according to technology used in each vehicle type was estimated taking into account the information from Lithuanian NIR 2015[86] assuming similar conditions with Lithuania`s vehicle fleet (Table 4.38).

**Table 4.38 Average percentage of vehicles equipped with air conditioning systems by vehicle type and technology**

| Technology | Passenger cars | Light Duty Vehicles <3,5t | Heavy duty vehicles 3,5 -12 t | Heavy duty vehicles >=12 t | Buses <=18 t | Buses >18 t |
|---|---|---|---|---|---|---|
| Convential 1990-1993 | 26 | 0 | 0 | 30 | 0 | 0 |

[86] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8812.php

| Technology | Passenger cars | Light Duty Vehicles <3,5t | Heavy duty vehicles 3,5 -12 t | Heavy duty vehicles >=12 t | Buses <=18 t | Buses >18 t |
|---|---|---|---|---|---|---|
| EURO 1 1993-1997 | 40 | 1 | 1 | 40 | 1 | 1 |
| EURO 2 1997-2001 | 56 | 9 | 9 | 53 | 9 | 9 |
| EURO 3 2001-2006 | 74 | 38 | 38 | 82 | 38 | 38 |
| EURO 4 2006-2011 | 93 | 77 | 77 | 98 | 77 | 77 |
| EURO 5 2011-2014 | 100 | 94 | 94 | 100 | 94 | 94 |
| EURO 6 Since 2014 | 100 | 94 | 94 | 100 | 94 | 94 |

Average amounts of HFC-134a in each vehicle type are summarized in Table 4.39.

**Table 4.39 HFC-134a average amount by vehicle type**

| Vehicle type | Average refrigerant amount (kg) |
|---|---|
| Passenger cars | 0.6 |
| Light Duty Vehicles <3,5t | 0.7 |
| Heavy duty vehicles 3,5 -12 t | 1.2 |
| Heavy duty vehicles >=12 t | 1.2 |
| Buses <=18 t | 8 |
| Buses >18 t | 13 |

*Emission factors and calculations*

Tier 2a – emission-factor approach from 2006 IPCC Guidelines for each vehicle type was used to estimate emissions from mobile air conditioniners. As most part of vehicle fleet in Latvia are second hand there are no data available on the original factory charge. HFC emissions from mobile air conditioning are estimated from stocks and disposal. According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. HFC-134a emissions from mobile air conditioning are estimate from following stages:

- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,}t$ – emissions at system disposal.

Equation 7.10 from 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$E_{total,t} = E_{Lifetime,t} + E_{End\text{-}of\text{-}life,t}$$

Emission factors and assumptions used in emission calculation from mobile air conditioning are as follows:

- HFC used in mobile air conditioning is HFC-134a ;
- Average emission factor during operation of equipment is 15%[87];
- 8% of total MACs are disposed every year[88];
- Average life time of transport applications 13 years[89];

[87] *2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for mobile air conditioners*
[88] *Confirmed by Latvian Freezing Equipment Engineers` Association*

- Residual charge of HFC in equipment being disposed 100%[90];
- $\eta_{rec,\ d} = 0$[91]

Equation from 2006 IPCC Guidelines for emission estimation stocks:

$$E_{lifetime,\ t} = B_t \times x / 100$$

*where:*
*$E_{lifetime}$ – amount of emissions during equipment operation (t)*
*Bt – amount of F-gases held in stocks in year t (tonnes)*
*x – losses during operation period (%)*

The amount of F-gases remained in MACs after the disposal every year is estimated by multiplying amount of MACs disposed with the approximate amount of F-gases remained in one appliance. It is assumed that 100% of F-gases remained in MACs after their lifetime.

Equation from 2006 IPCC Guidelines for emission estimation from disposal of MACs:

$$E_{end\text{-}of\text{-}life,t} = M_{t-d} \times p/100 \times (1-\eta_{rec,d}/100)$$

*where:*
*$E_{end\text{-}of\text{-}life,t}$– amount of emissions from system disposal (t)*
*Mt-d– amount of HFCs charged into domestic refrigerators and freezers in year (t-n) (tonnes)*
*P – residual charge of HFC in equipment being disposed of expressed in % of full charge (%)*
*ηrec,d – recovery efficiency at disposal*

In 2014 the total HFC-134a stock in all road vehicle types in Latvia amounts to 274.2 t. The HFC-134a emissions from stocks are 41.13 t. In 2014 the amount of HFC in disposed MACs in year was 8.78 t which according to assumption of 100% emission of disposal resulted in 8.78 t of HFC-134a (71.37 kt $CO_2$ eq.).

- *Stationary Air Conditioning (CRF 2.F.1.f)*

*Activity data*

Activity data for emission calculation from stationary air conditioning is taken from annual reports by F-gases operators according to Regulation (EC) No. 517/2014 and national legislation No.563[92]. 245 operators reported data of their activities with F-gases in 2014. Activity data for this category is derived during F-gases research (2016) when the proportion of HFCs used in stationary air conditioning were obtained directly contacting with operators who report the F-gases amounts within the legislation mentioned above.

*Emission factors and calculations*

Tier 2a – emission-factor approach from 2006 IPCC Guidelines was used to estimate emissions from stationary air conditioning. Emissions result from charging, lifetime and end-of-life of equipment and are calculated for each type of HFC separately.

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*89 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for mobile air conditioners*
*90 Confirmed by Latvian Freezing Equipment Engineers` Association*
*91 Confirmed by Latvian Freezing Equipment Engineers` Association*
*92 http://likumi.lv/ta/id/233736-noteikumi-par-ipasiem-ierobezojumiem-un-aizliegumiem-attieciba-uz-darbibam-ar-ozona-slani-noardosam-vielam-un-fluoretam-siltumn...*

According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. These emissions come from:

- $E_{charge,\ t}$ – emissions related to the refrigerant charge: connection and disconnection of the refrigerant container and the new equipment to be charged;
- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,}t$ – emissions at system disposal.

Equation 7.10 from 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$E_{total,t} = E_{Charge,t} + E_{Lifetime,t} + E_{End\text{-}of\text{-}life,t}$$

There are no HFC-containing equipment manufacturing companies in Latvia and all appliances used in stationary air conditioning are imported.

Emission factors and assumptions used in emission calculation from stationary air conditioners are as follows:

- HFCs mainly charged in Industrial Refrigeration are HFC-407c, HFC-410a, HFC-404a, HFC-134a, HFC-422d and HFC-417a;
- Average emission factor during charging of equipment is 0.6%[93];
- Average emission factor during operation of equipment is 8%[94];
- Average life time of stationary air conditioning applications 15 years[95];
- Residual charge of HFC in equipment being disposed 80%[96];
- Recovery efficiency at disposal 90%[97].

Equation from 2006 IPCC Guidelines for charging emissions estimation:

$$E_{Charged,\ t} = M_t \times k/100$$

*where:*
*$E_{charged}$ – emissions during system manufacture/assembly in year (kg)*
*Mt – amount of HFC-134a charged into a new equipment in year (kg)*
*k – charging losses (%)*

Equation from 2006 IPCC Guidelines for emission estimation stocks:

$$E_{lifetime,\ t} = B_t \times x / 100$$

*where:*
*$E_{lifetime}$ – amount of emissions during equipment operation (t)*
*Bt – amount of F-gases held in stocks in year t (tonnes)*
*x – losses during operation period (%)*

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*[93] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for residental and commercial air conditioners including heat pumps*
*[94] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9 – Average value applied for residental and commercial air conditioners including heat pumps*
*[95] Confirmed by Latvian Freezing Equipment Engineers` Association*
*[96] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9*
*[97] 2006 IPCC Guidelines, Volume 3, Chapter 7, Table 7.9*

The total amount of HFC filled into stationary air conditioners in 2014 amounts to 9.81 t constituting 0.06 t manufacturing emissions. HFC in stocks amounts to 98.15 t constituting 7.85 t operating emissions. Emissions from disposal or stationary air conditioners are not estimated due to lifetime of 15 years that has not been reached yet.

#### 4.7.1.3 Uncertainties and time series-consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for Refrigeration and air conditioning sector could arise to 50% according to expert judgement. Also uncertainty of emission factors for HFCs is assumed as 50%.

Time series of the estimated emissions are consistent because the same methodology, emission factors and data sources are used for sectors for all years in time series.

#### 4.7.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.F. sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

QA/QC check is performed according to 2006 IPCC Guidelines. All information on activity data and emission calculations are stored and archived in the common FTP folder. All findings are documented using check-lists which are archived and documented in centralized archiving system (common FTP folder).

All estimations of the emissions done in the LEGMC are checked on the logical mistakes by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in national legislation. All findings were documented and introduced in GHG inventory.

Quality manager from LEGMC has checked the data between CRF and NIR to ensure the consistency as well as QC actions were done in CRF in purpose to double check if all sub-applications are covered.

Currently using CRF Reporter software version 5.14 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

Under 2.F.1 Refrigeration and Air Conditioning only F-gases which are source of emissions are reported. Remaining F-gases are not added as child nodes according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

#### 4.7.1.5 Category-specific recalculations

Recalculations were made in all 2.F. subcategories due to implementation of F-gases research (2016) results. According to the research, activity data taken from annual reports by F-gases operators were split between the subcategories and the time series was recalculated at a level of 2006 IPCC Guidelines subcategories (Commercial, Industrial, Transport refrigeration and Stationary air conditioning). Emission factors were elaborated consulting with Latvian Freezing Equipment Engineers` Association.

Recalculation of refrigerant stocks and operating emissions for Commercial, Industrial, Transport refrigeration and Stationary air conditioning were made due to correction of methodology, based on cumulative calculation of the refrigerant amounts in operating systems over time. Recalculation made due to recommendation by TERT[98] during EU ESD[99] review in 2016.

Recalculations were made also for mobile air conditioners as more precise data regarding population of cars and distribution by vehicle types (passenger cars, LDV, HDV), age and vehicle categories according to emission control system (EURO classes) were obtained.

#### 4.7.1.6 Category-specific planned improvements

For the next inventory it is planned to perform additional cross-checks with other data sources in order to reassess and ensure completeness of the F-gases inventory.

### 4.7.2 Foam Blowing Agents (CRF 2.F.2)

#### 4.7.2.1 Category description

The category covers HFC emissions from PU foams and foaming of polyether for shoe soles. HFCs from PU foams are emitted only from the use of imported foams containing F-gases as there is no production of PU foams in Latvia.

The calculation of emissions under 2.F.2 was carried out for following gases:

- HFC-134a
- HFC-227ea
- HFC-245fa
- HFC-152a
- HFC-365mfc

[98] *Technical expert review team*
[99] *https://emrt.eea.europa.eu/*

In 2014 emissions totalled 0.96 kt $CO_2$ equivalent including 0.96 kt $CO_2$ equivalent from foaming of polyether for shoe soles and 0.001 kt $CO_2$ equivalent resulting from PU foam use in construction (building).

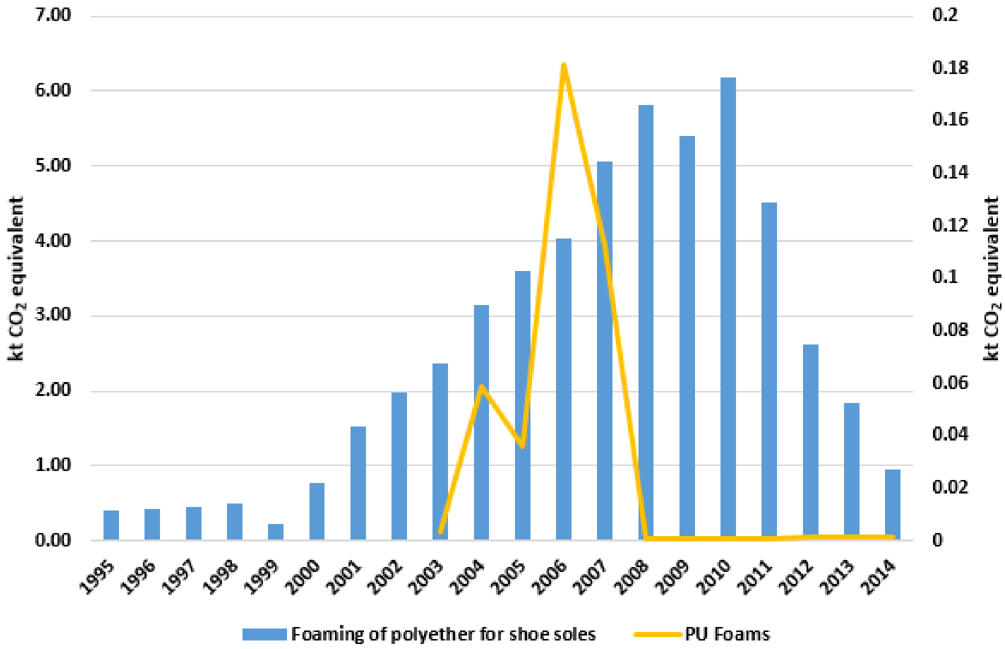


**Figure 4.16 HFC emissions from 2.F.2[100] (kt $CO_2$ eq.)**

Manufacturing of shoes (shoe soles) containing HFC-134a occurred in 1995-2002 when comparatively smaller amounts of HFC were emitted. After 2002 emissions from stocks and disposal were estimated and emissions started to increase reaching peak level in 2010. According to F-gases Regulation (EU) No 517/2014 which repeals Regulation (EC) No 842/2006 from 4 July 2006 it is prohibited to place on the EU market footwear containing F-gases. According to prohibitions described in EU regulations it was assumed that amount of shoes containing HFC-134a started to decrease since 2007 however emissions from disposal were still at previous level.

Between 2013 and 2014 the emissions decreased by 91% mostly due to decrease of emissions from HFC-134a containing footwear disposal (Figure 4.16).

Emissions from PU foams are estimated starting from 2003 when data from Chemicals Register become avalaible. Since then emissions have been increased very rapidly due to economic development and increased activity in building sector reaching the highest level in 2006. Afterwards emissions started to decrease and since 2008 rather small amounts are emitted. Fluctuations between years are mostly related to consumed foam amounts in construction.

#### 4.7.2.2 Methodological issues

An overview of the methods used and gases reported under 2.F.2 sector is presented in Table 4.40.

*[100] PU Foams on secundary axis*

**Table 4.40 Summary of emission calculation methods and gases in CFR 2.F.2**

| CRF Category/subcategory | Method used | Gases reported |
|---|---|---|
| 2.F.1 Foam Blowing agents | | |
| *2.F.2.a Closed Cells* | Tier 2a | HFC-134a<br>HFC-227ea<br>HFC-245fa<br>HFC-152a<br>HFC-365mfc |

- *PU foams*

*Activity data*

The imported amount of construction foams is obtained from Chemicals Register. No export and production data is reported to the Chemicals Register therefore only imported amount can be obtained. So only emissions from use of PU foams (stocks) are calculated.

Although the activity in building sector in previous years has radically increased, emission estimations for PU foams can be done starting from 2003 due to the lack of activity data of imported and used building foams or foams used in windows manufacturing as well as lack of data on foams containing F-gases. It is assumed that all the construction foams imported are closed cells foams (used in insulation applications) according to NACE classification. The data on foams imported as well as the average percentage of F-gases in foams were obtained from Chemicals Register.

*Emission factors and calculations*

HFC emissions are calculated from foams in stocks. The emission calculations were done according to 2006 IPCC Guidelines Tier 2a method using activity data on imported foams and default emission factor – annual losses 4.5% of the original HFC charge/year[101].

Equation from 2006 IPCC Guidelines for emissions from closed-cell foam in year was used:

$$Emissions_t = Bank_t \times EF_{AL}$$

*where:*
*$Emissions_t$ = emissions from closed-cell foam in year t, tonnes*
*$Bank_t$ = HFC charge blown into closed-cell foam manufacturing between year t and year t-n, tonnes*
*$EF_{AL}$ = annual loss emission factor, fraction*
*t = current year*

The product lifetime of foam is 20 years. As in that time Latvia was part of Soviet Union the specific data was not collected as well as it is believable that the foam blowing did not occur in country or it occur in very negligible amounts. Therefore decommissioning losses from foams are not estimated (NE).

- *Foaming of polyether (for shoe soles)*

*Activity data*

Activity data for emission estimation from foaming of polyether for shoe soles is taken from CSB databases about produced imported and exported amount of shoes[102]. Assumptions and

*[101] 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Emissions of Fluorinated Substitutes for Ozone Depleting Substances (Volume 3) Industrial Processes and Product Use, p.7.35*

default leakage factors are taken from Danish project "The Greenhouse gases: HFCs, PFCs and $SF_6$" [103].

The manufacturing of shoe soles containing HFC-134a occurred in Latvia in 1995-2002. The amount of produced shoes (shoe soles) is obtained by CSB. According to Danish project[103] it was assumed that 5% of all shoes with plastic, rubber and leather soles contain polyether containing 8 g of HFC-134a per shoe.

*Emission factors and calculations*

Total amount of HFC-134a used for manufacturing of shoe soles can be estimated by using equation:

$$HFC_{filled} = Sh_{produced} \times d_{HFC} \times HFC_{sh}$$

*where:*
$HFC_{filled}$ – *total amount of HFC-134a used in manufacturing of shoes (t)*
$Sh_{produced}$ – *amount of produced shoes (pieces)*
$d_{HFC}$ – *amount of shoes containing HFC-134a (%)*
$HFC_{sh}$ – *amount of HFC-134a filled in one shoe sole (t)*

Danish default leakage factor for HFC-134a emitted during manufacturing is 15%.

The HFC-134a emissions from manufacturing of shoe soles can be estimated by using equation:

$$E_{production} = HFC_{filled} \times k$$

*where:*
$E_{production}$ – *HFC-134a emissions from shoe manufacturing (t)*
$HFC_{filled}$ – *total amount of HFC used in manufacturing of shoes (t)*
*k – leakage from shoes production (%)*

The amount of imported, exported and produced shoes (shoe soles) is obtained by CSB. According to Danish project it was assumed that 5% of all shoes with plastic, rubber and leather soles contain polyether containing 8 g of HFC-134a per shoe.

Total amount of HFC-134a held in stocks in shoe soles can be estimated by using equation:

$$HFC_{stocks} = HFC_{filled} + HFC_{imported} - HFC_{exported}$$

*where:*
$HFC_{stocks}$ – *total amount of HFC-134 held in stocks in shoe soles and used in country in particular year (t)*
$HFC_{filled}$ – *total amount of HFC-134a filled in shoes during manufacture of shoes (t)*
$HFC_{imported}$ – *total amount of HFC-134a imported in shoes (t)*
$HFC_{exported}$ – *total amount of HFC-134a exported in shoes (t)*

Danish default leakage factor for HFC-134a emitted during lifetime is 4.5% (lifetime is 3 years) or 1.5% annually.

The HFC-134a emissions from stocks held in shoe soles can be estimated by using equation:

$$E_{stocks} = HFC_{stocks} \times x$$

[102] *http://data.csb.gov.lv/Selection.aspx?px_tableid=atirdz\Detaliz%C4%93ta+statistika\8+z%C4%ABmju+l%C4%ABmen%C4%AB\2012_imp_8.px&px_language=en&px_type=PX&px_db=atirdz&rxid=cdcb978c-22b0-416a-aacc-aa650d3e2ce0*
[103] *http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/udgiv/publications/2009/978-87-7052-962-4/html/bred01_eng.htm*

*where:*
*$E_{stocks}$ – HFC-134a emissions from shoe lifetime (t)*
*$HFC_{stocks}$ – total amount of HFC-134 held in stocks in shoe soles and used in country in particular year (t)*
*x – leakage from using of shoes during its lifetime (%)*

According to above mentioned Danish project average lifetime of shoes is 3 years. It means that for HFC-134a emission estimation the amount of HFC-134a remained in shoe soles after their lifetime in year$^{-3}$ has to be known. As CSB doesn't have so old data the approximate amount back to year 1992 is extrapolated taken into account the amount curve in 1995-2000.

Total amount of HFC-134a left in shoe soles after their lifetime ends can be estimated by using equation:

$$HFC_{remained} = HFC_{stocks} \times (1-x)$$

*where:*
*$HFC_{remained}$ – total amount of HFC-134a remained in shoes after their lifetime in year$^{-3}$ (t)*
*(1-x) – percentage amount of HFC left in shoes (%)*

For the emission estimation from disposal default Danish emission factor 71.5% is used as some part of shoes are destroyed in incineration and thereby not released as emissions.

The HFC-134a emissions from disposal of shoe soles can be estimated by using equation:

$$E_{disposal} = HFC_{remained} \times Q$$

*where:*
*$E_{disposal}$ – total amount of HFC-134a emissions from disposal*
*$HFC_{remained}$ – total amount of HFC-134a remained in shoes after their lifetime in year$^{-3}$ (t)*
*Q – leakage from disposal (%)*

#### 4.7.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for Foam Blowing sector could arise to 50% according to expert judgement. Also uncertainty of emission factors for HFCs is assumed as 50%.

Time series of the estimated emissions are consistent because the same methodology, emission factors and data sources are used for sectors for all years in time series.

#### 4.7.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.F. sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

More detailed description can be found under chapter 4.7.1.4.

Currently using CRF Reporter software version 5.14 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF

Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

Under 2.F.2 Foam blowing Agents, 2.F.2.a Closed Cells only F-gases which are source of emissions are reported. Remaining F-gases and F-gases under 2.F.2.b Open Cells are not occurring and are not added as child nodes according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

#### 4.7.2.5 Category-specific recalculations

Foaming of polyether for shoe soles is reported under 2.F.2 Foam blowing agents according to allocation suggested by TERT during EU ESD review in 2015. Therefore HFC-134a emissions are summed up from both – PU foams and foaming of polyether for shoe soles in this submission.

#### 4.7.2.6 Category-specific planned improvements

No planned improvements of this category.

### 4.7.3 Fire Protection (CRF 2.F.3)

#### 4.7.3.1 Category description

The category covers HFC emissions from use of fire protecting equipment. In 2014 emissions totalled 0.03 kt $CO_2$ equivalent giving only 0,01% from total HFC emissions in 2.F (Figure 4.17). As the emissions from fire suppression systems occur when the system is discharged in case of fire or accidentally, emissions are estimated only from for operating of fire protection systems using HFC-227ea and HFC-23.

Emission time series started in 2001 when the first data regarding use of Fire protection systems containing HFCs was received during the first F-gases research (2004). Since then strong emission fluctuations have been observed. Compared to 2013 in 2014 the emissions have decreased by 124% mainly due to decrease in activity data in this sector.

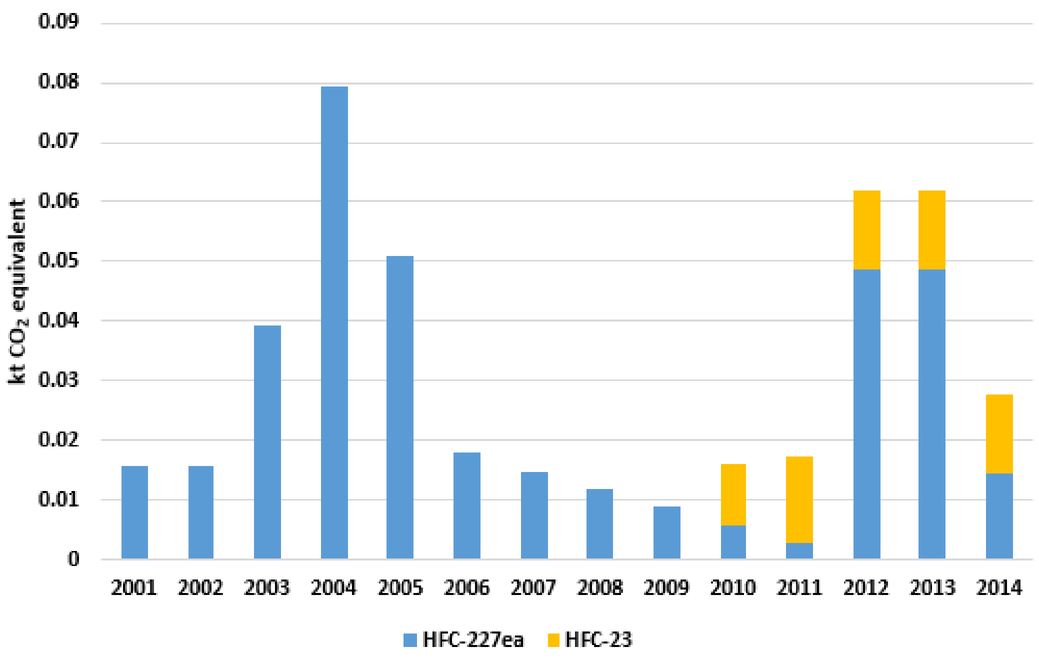


**Figure 4.17 HFC emissions from 2.F.3 (kt $CO_2$ eq.)**

Emissions from fire extinguishing are problematic to estimate due to the fact that there is only statistical information of the registered fire extinguishing equipment (pieces) in Latvia done by State Fire and Rescue Service. Type of substance used in equipment isn't registered.

According to Regulation No.563 of the Cabinet of Ministers of Latvia companies who use F gases in stationary fire protection equipment shall report amounts used to responsible institution (LEGMC) each year till 31st of March. Information from LEGMC database available since 2010. Till then historical data from basic F-gases research (2004) was used and extrapolation was done.

### 4.7.3.2 Methodological issues

An overview of the methods used and gases reported under 2.F.3 sector is presented in Table 4.41.

**Table 4.41 Summary of emission calculation methods in CFR 2.F.3**

| CRF Category/subcategory | Method used | Gases reported |
|---|---|---|
| 2.F.3 Fire Protection | Tier 2a | HFC-227ea, HFC-23 |

*Activity data*

During the F-gases research (2004) it was found out that there is no manufacturing of fire extinguishers containing F-gases. 19 enterprises were questioned including only manufacturer of fire extinguishers. According to responses received a little amount of fire extinguishers are filled with F-gases. Only 2 enterprises reported the amount of HFC-227ea in their installed equipment in particular year and amount of HFC-227ea held in stocks (containers) of fire extinguishing equipment. It was reported that no charging was done for the installed equipment. Fire extinguishers were installed already filled with F-gases and there weren't any necessity to recharge them. Therefore only emissions from stocks were calculated.

Amount of F-gases in annually installed equipment and amount held in containers is used as activity data for emission estimations from stocks. Activity data for historical years (2001-2006) is taken from the first F gases research done in 2004. Since 2010 data is taken from annual F-gases reports, where operators annually report F-gases amounts used in their equipment.

*Emission factors and calculations*

It is assumed that 2% from total stocks is emitted during equipment operations annually according to 2006 IPCC Guidelines [104].

Equation from 2006 IPCC Guidelines for emission estimation from stocks:

$$E_{lifetime,\,t} = B_t \times x / 100$$

*where:*
*$E_{lifetime}$ – amount of emissions during equipment operation (t)*
*Bt – amount of F-gases held in stocks in year t (tonnes)*
*x – losses during operation period (%)*

The lifetime of the equipment is 20 years therefore emissions at system disposal were not estimated.

#### 4.7.3.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for Fire Protection sector could arise to 50% according to expert judgement. Also uncertainty of emission factors for HFCs is assumed as 50%.

Time series of the estimated emissions are consistent because the same methodology, emission factors and data sources are used for sectors for all years in time series.

#### 4.7.3.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.F. sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

More detailed description can be found under chapter 4.7.1.4.

Currently using CRF Reporter software version 5.14 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF Reporter User manual says that if disaggregated data is not available for certain categories,

[104] *2006 IPCC Guidelines for National Greenhouse Gas Inventories: Emissions of Fluorinated Substitutes for Ozone Depleting Substances (Volume 3) Industrial Processes and Product Use, p.7.63*

the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

Under 2.F.3 Fire Protection only F-gases which are source of emissions are reported. Remaining F-gases are not occurring and are not added as child nodes according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

#### 4.7.3.5 Category-specific recalculations

HFC-23 emissions were calculated starting from 2010 as activity data was obtained from annual reports by F-gases operators.

#### 4.7.3.6 Category-specific planned improvements

No improvements are planned for this category.

### 4.7.4 Aerosols (Metered Dose Inhalers CRF 2.F.4.a)

#### 4.7.4.1 Category description

This category covers HFC-134a emissions from metered dose inhalers. There are no other HFC containing aerosol types used in Latvia.

In 2014 emissions totalled 4.70 kt $CO_2$ equivalent giving 2.2% from total HFC emissions in 2.F (Figure 4.18). The 2014 emissions increased 25% compared to 2013 due to the increased amount of imported HFC-134a in products. Emissions have increased compared to the base year as well. The fluctuation in the time series is due to observed changes in consumption of HFC containing metered dose inhalers.

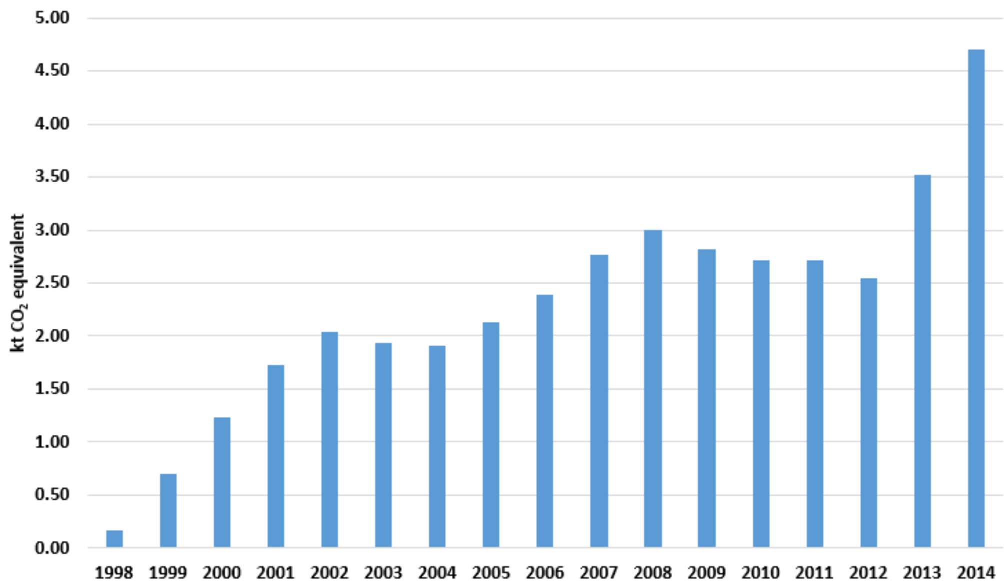


**Figure 4.18 HFC emissions from 2.F.4.a (kt $CO_2$ eq.)**

During the first F-gases research (2004) it was found out that there is no production of F-gases containing aerosols in Latvia. All aerosols used in Latvia are imported. It is very difficult to collect the data of imported aerosols as it is necessary to separate HFCs containing aerosols from others. It is almost impossible to get the information from all households and importers of industrial aerosols in Latvia as Central Custom Service registers only all imported aerosols with one custom code not dividing them by type or by substances containing. Also since Latvia is in Schengen zone only imported amount from Third Countries is registered.

Only the aerosols used in medicine for asthmatics are estimated and reported under this category. During the first F-gases investigation number of inhalers containing HFC–134a was obtained as well as average amount of HFC-134a filled in one inhaler divided by the type of medicine. All the inhalers are imported as no inhalers for asthmatics are produced in Latvia.

### 4.7.4.2 Methodological issues

An overview of the methods used and gases reported under 2.F.4 sector is presented in Table 4.42.

**Table 4.42 Summary of emission calculation methods in CFR 2.F.4**

| CRF Category/subcategory | Method used | Gases reported |
|---|---|---|
| 2.F.4 Aerosols | Tier 2a | HFC-134a |

*Activity data*

For years 1998-2006 data of imported inhalers reported by importers of medical preparations was used as activity data for emission calculations. From 2007 till 2014 data for emission estimations annually is reported by State Agency of Medicines of Latvia. All importers of the medical preparations shall report the imported and sold amount of medicines so these data are very precise.

Total amount of HFC-134a used in metered dose inhalers in particular year can be estimated as the imported amount of inhalers containing HFC-134a and an average amount of HFC-134a filled in each type of inhalers is known.

*Emission factoirs and calculations*

Equation for total amount HFC-134a used as medical preparation:

$$HFC_{sold} = \Sigma\ MDI_{sold} \times HFC_{filled}$$

*where:*
*$HFC_{sold}$ – total amount of HFC sold/imported in country (t)*
*$MDI_{sold}$ – amount of sold/imported particular type of metered dose inhalers containing F-gases (pieces)*
*$HFC_{filled}$ – amount of HFCs filled in particular type of inhaler (t)*

According to 2006 IPCC Guidelines 50%[105] leakage from metered dose inhalers sold in particular year and 50% from inhalers sold in year before particular year is assumed.

Equation from 2006 IPCC Guidelines for metered dose inhalers emissions:

$$Emissions_t = S_t \times EF + S_{t-1} \times (1-EF)$$

*where:*
*$Emissions_t$ = emissions in year t, tonnes*
*St – quantity of HFC and PFC contained in aerosol products sold in year t, tonnes*
*$S_{t-1}$ – quantity of HFC and PFC contained in aerosol products sold in year t-1, tonnes*
*EF = emission factor (=fraction of chemical emitted during the first year), fraction*

#### 4.7.4.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for Aerosol sector could arise to 50% according to expert judgement. Also uncertainty of emission factors for HFCs is assumed as 50%.

Time series of the estimated emissions are consistent because the same methodology, emission factors and data sources are used for sectors for all years in time series.

#### 4.7.4.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.F. sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

More detailed description can be found under chapter 4.7.1.4.

Currently using CRF Reporter software version 5.14 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done

*[105] 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Emissions of Fluorinated Substitutes for Ozone Depleting Substances (Volume 3) Industrial Processes and Product Use, p.7.29*

by directly entering data in the green cells (i.e. overwriting formulas). Entering data in green cells is only possible when the parent node to which the grid with green cells belongs does not have any child nodes.

Under 2.F.4 Aerosols only F-gases which are source of emissions are reported. Remaining F-gases are not occurring and are not added as child nodes according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

#### 4.7.4.5 Category-specific recalculations

No recalculations are done for this category.

#### 4.7.4.6 Category-specific planned improvements

No improvements are planned for this category.

## *4.8 OTHER PRODUCT MANUFACTURE AND USE (2.G)*

Under 2.G Latvia reports emissions from sulphur hexafluoride ($SF_6$) and nitrus oxide ($N_2O$), occurring in following sectors:

- Electrical equipment (CRF 2.G.1);
- $N_2O$ from product uses (CRF 2.G.3);

$SF_6$ and PFCs emissions from Other product use (2.G.2) and Other (2.G.4) are not occurring in Latvia. Under 2.G only F-gases which are source of emissions are reported. Remaining F-gases are not occurring and are not added as child nodes in CRF Reporter according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing.

In 2014 GHG emissions from other product manufacture and use amounted 10.59 kt $CO_2$ eq (0.1%) from Latvia`s total $CO_2$ equivalent emissions without LULUCF. In 2014 compared to 2013 emissions have increased by 1.3%, but compared to 1990 emissions have increased by 87.7%.

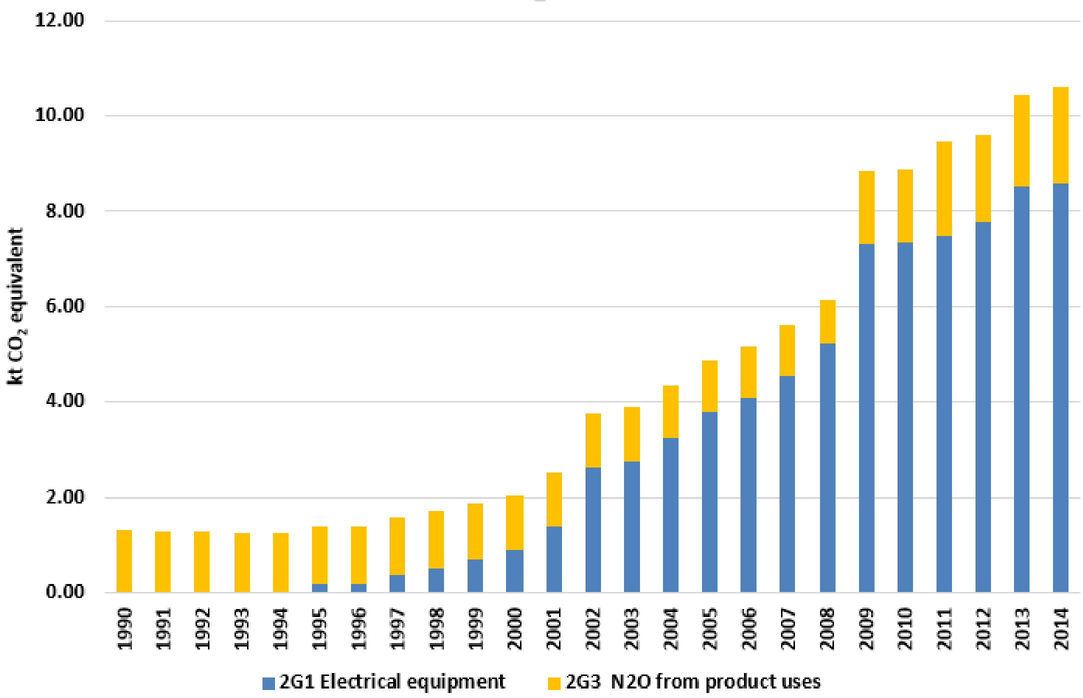


**Figure 4.19 Emissions from 2.G Other product manufacture and use (kt $CO_2$ eq.)**

The total emissions from 2.G have increased since 1990 (see Figure 4.19 and Table 4.44). Emission trend could mainly associated with increase in activity data received from companies. Emission fluctuations in the $N_2O$ From Product Uses sector are linked with the economic situation of the country.

Reported emissions, calculation methods and type of emission factors for the 2.G Other Product Manufacture and Use in the Latvian inventory are summarized in Table 4.43.

**Table 4.43 GHG emission categories, methods and gases reported from 2.G Other Product Manufacture and Use**

| Category | Method used | Gases reported |
|---|---|---|
| **G. Other Product Manufacture and Use** | | |
| 1. Electrical Equipment | Tier1 | $SF_6$ |
| 3. $N_2O$ from Product Uses (Medical Applications) | CS | $N_2O$ |

**Table 4.44 Total emissions from 2.G Other Product Manufacture and Use, 1990-2014 (kt $CO_2$ eq.)**

| | 2G Other Product manufacture and Use | 2.G.1 Electrical Equipment | 2.G.3 $N_2O$ from Product Uses |
|---|---|---|---|
| 1990 | 1.30 | NE | 1.30 |
| 1995 | 1.40 | 0.17 | 1.22 |
| 2000 | 2.05 | 0.88 | 1.16 |
| 2001 | 2.54 | 1.39 | 1.15 |
| 2002 | 3.75 | 2.62 | 1.13 |
| 2003 | 3.88 | 2.76 | 1.12 |
| 2004 | 4.36 | 3.25 | 1.11 |

| | 2G Other Product manufacture and Use | 2.G.1 Electrical Equipment | 2.G.3 $N_2O$ from Product Uses |
|---|---|---|---|
| 2005 | 4.88 | 3.78 | 1.10 |
| 2006 | 5.16 | 4.07 | 1.09 |
| 2007 | 5.63 | 4.55 | 1.08 |
| 2008 | 6.13 | 5.23 | 0.89 |
| 2009 | 8.85 | 7.33 | 1.53 |
| 2010 | 8.87 | 7.35 | 1.51 |
| 2011 | 9.45 | 7.47 | 1.98 |
| 2012 | 9.59 | 7.78 | 1.82 |
| 2013 | 10.46 | 8.50 | 1.95 |
| 2014 | 10.59 | 8.58 | 2.01 |
| Share of total IPPU % in 2014 | 1.3% | 1.0% | 0.2% |
| 2014 versus 2013 | +1.3% | +0.9% | +3.0% |
| 2014 versus 1990 | +713% | +4848% | +55% |

## 4.8.1 Electrical Equipment (CRF 2.G.1)

### 4.8.1.1 Category description

This category covers emissions of sulphur hexafluoride ($SF_6$) from electrical equipment used in high and medium voltage commutation and control installations. Equipment is not manufactured in Latvia. $SF_6$ emissions are estimated from charging and lifetime. There is only one enterprise where huge amount of $SF_6$ is filled. Installations are not produced in Latvia and the old equipment without fill of the $SF_6$ was dismantled at the beginning of 1990s. Only starting from 1992 new equipment was gradually installed. Since 1992, it uses small amount of $SF_6$ in electrical equipment, but since 1995 used amount is increasing.

In 2014 $SF_6$ emissions from Electrical Equipment constituted 8.58 kt $CO_2$ eq (81% from total 2.G emissions). Emissions have grown since 1995 by 98% and by 0.9% compared to 2013 (Figure 4.20 and Table 4.45).

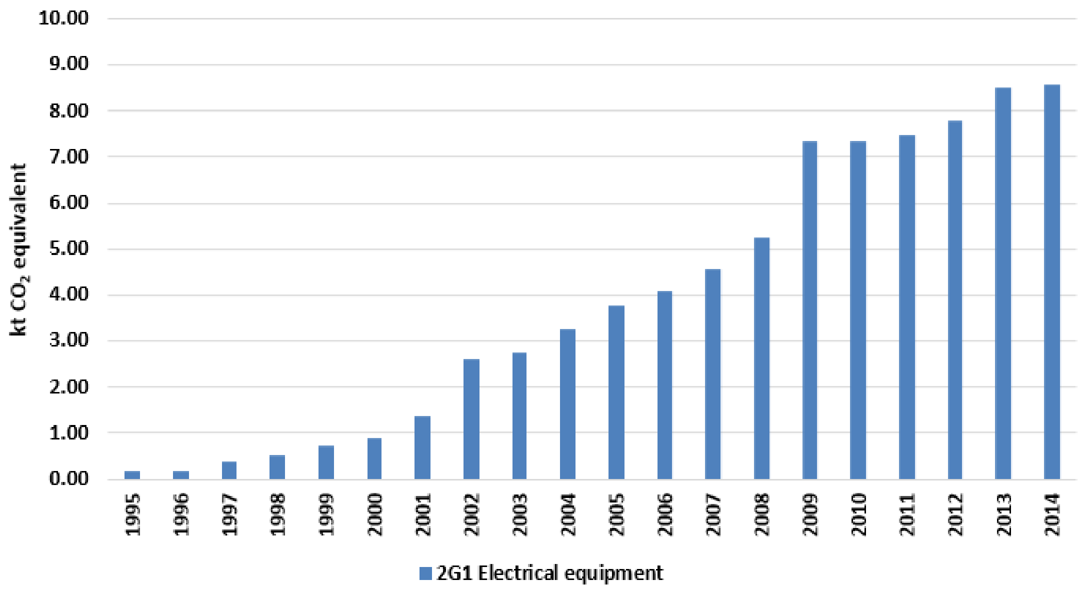


**Figure 4.20 $SF_6$ emissons from 2.G.1 (kt $CO_2$ eq.)**

**Table 4.45 $SF_6$ emissions from 2.G.1 Electrical Equipment, 1995-2014 (kt $CO_2$ eq.)**

| | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Electrical equipment** | 0.17 | 0.88 | 1.39 | 2.62 | 2.76 | 3.25 | 3.78 | 4.07 | 4.55 | 5.23 | 7.33 | 7.35 | 7.47 | 7.78 | 8.50 | 8.58 |

#### 4.8.1.2 Methodological issues

An overview of the methods used and gases reported under 2.G.1 sector is presented in Table 4.46.

**Table 4.46 Summary of emission calculation methods and gases in CFR 2.G.1**

| CRF Category/subcategory | Method used | Gases reported |
|---|---|---|
| 2.F.1 Electrical Equipment | Tier1 | $SF_6$ |

*Activity data*

Enterprise imports equipment already filled with $SF_6$. There is no manufacturing of the electric equipment containing $SF_6$ in Latvia, therefore only emissions from charging and operating were estimated using amount of $SF_6$ in newly installed equipment as activity data reported by the company. For years 2003-2014 enterprise reports the emergency leakage from electrical equipment which are also reported as operating emissions.

*Emission factors and calculations*

For emission estimations the Tier1 default emission factor method from 2006 IPCC Guidelines was used. Emissions are estimated by multiplying default regional emission factor (for Europe) by amount of $SF_6$ used in equipment in enterprise. The emissions are estimated by splitting data into the sealed pressure electrical equipment (MV switchgear) and closed pressure electrical equipment (HV switchgear) containing the $SF_6$ due to the different emission factors for each of these installations in 2006 IPCC Guidelines. For HV switchgears 2.6 %, but for MV switchgears 0.2% emission factor was used.

Equation from 2006 IPCC Guidelines for emission estimation from charging:

$$E_{charged,\ t} = M_t \times k / 100$$

*where:*
*$E_{charged}$ – emissions during system manufacture/assembly in year (kg)*
*$M_t$ – amount of HFC-134a charged into a new equipment in year (kg)*
*k – charging losses (%)*

Equation from 2006 IPCC Guidelines for emission estimation from stocks:

$$E_{lifetime,\ t} = B_t \times x / 100$$

*where:*
*$E_{lifetime}$ – amount of emissions during equipment operation (t)*
*$B_t$ – amount of F-gases held in stocks in year t (tonnes)*
*x – losses during operation period (%)*

Lifetime of used equipment is 30 years and no equipment was dismantled yet therefore emissions from disposal are marked "NO" in CRF Reporter.

#### 4.8.1.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

As there is only one facility in the country which uses $SF_6$ in their technology and reports the data on $SF_6$ usage directly to LEGMC, it is assumed that data used for emission estimation under this subcategory is more precise. Uncertainty of activity data for $SF_6$ from electrical equipment is assumed as ±2% for AD, but EF uncertainty could arise up to 30% according to the 2006 IPCC Guidelines.

Time series of the estimated emissions are consistent because the same methodology, emission factors and data sources are used for sectors for all years in time series.

#### 4.8.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.G. sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

More detailed description can be found under chapter 4.7.1.4.

Currently using CRF Reporter software version 5.14 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

Under 2.G.1 Electrical equipment only F-gases which are source of emissions are reported. Remaining F-gases are not occurring and are not added as child nodes according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

#### 4.8.1.5 Category-specific recalculations

No recalculations were done.

#### 4.8.1.6 Category-specific planned improvements

No improvements planned for this category.

## 4.8.2 $N_2O$ From Product Uses (CRF 2.G.3)

### 4.8.2.1 Category description

The $N_2O$ emissions under CRF 2.G.3 produce $N_2O$ from product uses: Medical applications. $N_2O$ emissions from anaesthesia formed a negligible part of total GHG emissions in Latvia. In 2014 these emissions totalled 2.01 kt $CO_2$ eq.

### 4.8.2.2 Methodological issues

$N_2O$ emissions from medical applications were estimated taking into account the amount of $N_2O$ sold. According to 2006 IPCC Guidelines, it was assumed that 100% of $N_2O$ sold for anaesthesia was emitted to the air, therefore activity data is equal to estimated emissions. The data on the $N_2O$ sales was available since 2007. Activity data was provided by the State Agency of Medicines of Latvia. The estimation of emissions is based on the assumption that all used $N_2O$ is emitted to the atmosphere in the same year when it is produced or imported in Latvia.

To obtain a comparable data in time series for years 1990-2006 assume that base year for $N_2O$ Emissions is year 2007, $N_2O$ emissions for years 1990-2006 were calculated proportionally, taking into account the number of inhabitants provided by CSB.

### 4.8.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of available activity data under CRF 2.G.3 sub-sector was ±2% in 2014. Emission factor uncertainty is assumed to be 2%. Time series consistency was ensured by using one method for all time series.

### 4.8.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the Other product manufacture and use (2.G.3) sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in the national legislation. All findings were documented and introduced in GHG inventory. All corrections are archived in centralized archiving system (common FTP folder).

#### 4.8.2.5 Category-specific recalculations

During quality control procedures mistakes in $N_2O$ emission calculation were found and therefore emissions were recalculated for all time series.

#### 4.8.2.6 Category-specific planned improvements

No improvements are planned under CRF 2.G.3.

## *4.9 OTHER PRODUCTION (CRF 2.H)*

### 4.9.1 Category description

Other Production sub-sector includes indirect emissions from:

- Pulp and Paper (2.H.1);
- Food and beverages industry (2.H.2).

NMVOC emissions constitute 1.32 kt in 2014 and decreased by 2.8% comparing with 2013 and by 61.1% comparing with 1990.

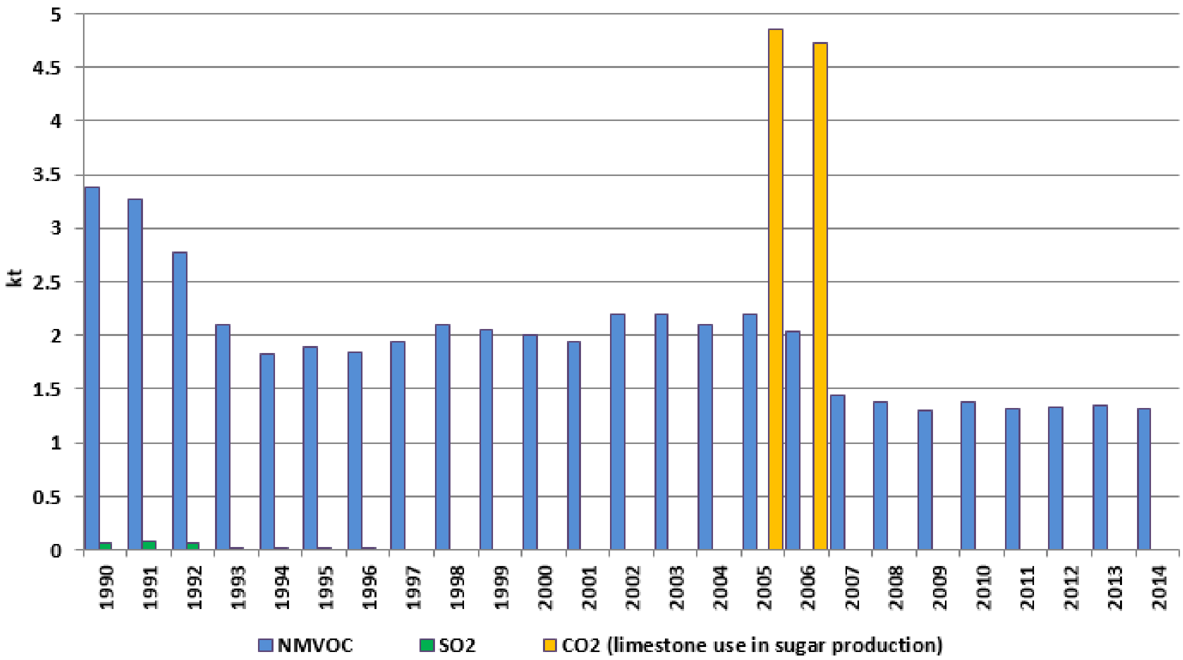


**Figure 4.21 Total emissions from 2.H Other Production in 1990–2014 (kt)**

Considerable fluctuations occurred in time period 1991–1993 due to changes in economic situation in country (Figure 4.21). Decrease of NMVOC emissions in time period 1999 – 2001 is explained with decresing demand of Food and beverages export to CIS countries. For the years in time period 2002–2004 NMVOC emissions were stable. NMVOC emissions decreased by 36.9% in 2005-2008 that is explained with decrease of produced spirits by 28.4% and closure of sugar production plants. Sugar is no longer produced in Latvia since 2007. For time period 2005-2006 data of used limestone in sugar production are reported. $CO_2$ emissions were calculated as two sugar production plants entered into ETS as operators and detailed information became available from annual GHG reports. After these two years sugar production plants stopped their activities and were closed. Since 2007 the total amount of food and beverages industry sector decrease. That could be explained with economic crisis in 2008-2009 as well with rise in prices of national and imported production.

$SO_2$ emissions are reported for time period 1990–1996 when pulp and paper industry were closed due to facility closes. In latest years wood pulp and paper industry is developing again still wood pulp is imported and not produced in country so $SO_2$ emissions that occurred in pulp production processes are not emitted. Since 2010 situation are quite stable in food and drink industry.

### 4.9.2 Methodological issues

Reported emissions, calculation methods and type of emission factors for the 2.H Other in the Latvian inventory are summarized in Table 4.47.

**Table 4.47 GHG emission categories, methods and gases reported from 2.H Other**

| Category | Method used | Gases reported |
|---|---|---|
| | **H. Other** | |
| 1.Pulp & Paper | Tier1 | $SO_2$ |
| 2.Food and beverages industry | Tier1 | NMVOC, $CO_2$ |

*Methods*

NMVOC emissions from the food and beverages industry as well as $SO_2$ emissions from pulp and paper are calculated. Emissions are calculated according to IPCC 1996.

*Emission factors*

$SO_2$ emission factor 0.03 (t/t) is taken from IPCC 1996[106].

The NMVOC emission factors (Table 4.48) are taken from the EMEP/CORINAIR 2013[107] with exception of NMVOC emission factor for spirits production. NMVOC emission factor from EMEP/CORINAIR 2007 that corresponds to other spirits was used. CSB provided aggregated statistical data where it can be seen that 95.5% of all spirits produced in Latvia is produced from grains (sheer alcohol or spirits) and no brandy and whiskey is produced in Latvia. That's why emission factor for Other Spirits 0.4 kg/hl (alcohol) is used.

**Table 4.48 NMVOC emission factors for food and drink industries**

| Production | Emission factors |
|---|---|
| **Wine** | 0.08 kg/hl |
| **Beer** | 0.035 kg/hl |
| **Spirits** | 0.4 kg/hl |
| **Meat, fish, poultry** | 0.3 kg/t |
| **Sugar** | 10 kg/t |
| **Cakes, biscuits, breakfast cereals** | 1 kg/t |
| **Bread** | 8 kg/t |
| **Animal forage** | 1 kg/t |

[106] *http://www.ipcc-nggip.iges.or.jp/public/gl/invs5b.html (p.2.39, Table 2-24)*
[107] *http://www.eea.europa.eu/publications/emep-eea-guidebook-2013, 2.H.2 Food and beverage industry (p.14-21)*

*Activity data*

Activity data for calculation of the NMVOC emissions from the food and drink industry is obtained from the CSB. Activity data of pulp and paper sub-sector also were taken from CSB (Table 4.49). LEGMC has signed an agreement with CSB to get data of total production of products from sectors where data are confidential.

Still for the 2014 data for the category – wine production, was classified as confidential and not available for the LEGMC. That's why for this category 2006 year's data was used also for 2007-2014.

**Table 4.49 Activity data of 2.H Other Production sector**

| | Pulp and Paper | Wine | Beer | Spirits | Meat, fish, poultry | Sugar | Limestone use in sugar production | Cakes, biscuits, breakfast cereals | Bread | Animal forage |
|---|---|---|---|---|---|---|---|---|---|---|
| | kt | 1000 hl | 1000 hl | 1000 hl | kt | kt | kt | kt | kt | kt |
| **1990** | 36.6 | 19.9 | 87.4 | 324.5 | 569.3 | 31.0 | NO | 54.8 | 314.0 | 200.0 |
| **1995** | 1.5 | 159.2 | 652.8 | 341.5 | 82.8 | 29.3 | NO | 24.4 | 145.4 | 214.4 |
| **2000** | NO | C | 945.1 | C | 197.3 | C | NO | 24.3 | 121.1 | 173.8 |
| **2005** | NO | C | 1293.3 | C | 243.8 | C | 11.0 | 53.6 | 116.3 | 248.6 |
| **2006** | NO | C | 1383.0 | C | 288.4 | C | 10.7 | 45.0 | 107.3 | 244.2 |
| **2007** | NO | C | 1414.3 | C | 286.0 | NO | NO | 46.5 | 102.3 | 336.8 |
| **2008** | NO | C | 1333.8 | C | 297.7 | NO | NO | 38.5 | 100.7 | 307.3 |
| **2009** | NO | C | 1292.4 | C | 253.5 | NO | NO | 33.3 | 95.9 | 299.3 |
| **2010** | NO | C | 1484.9 | C | 252.7 | NO | NO | 38.0 | 90.0 | 409.8 |
| **2011** | NO | C | 1626.6 | C | 261.5 | NO | NO | 39.7 | 88.6 | 360.9 |
| **2012** | NO | C | 1488.5 | C | 264.3 | NO | NO | 44.5 | 91.4 | 348.2 |
| **2013** | NO | C | 1513.7 | C | 286.2 | NO | NO | 56.4 | 88.1 | 380.1 |
| **2014** | NO | C | 967.5 | C | 270.7 | NO | NO | 50.4 | 84.9 | 379.5 |

### 4.9.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of activity data was assumed as 2% for 1990-2006 because statistical data from CSB were used. For 2007-2008 the uncertainty is assumed higher – 10%, as no precise information is available regarding wine production. $SO_2$ and NMVOC emission factor uncertainty were assigned as 50% because default emission factors from IPCC 1996 were used.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. GHG emissions from all sectors are estimated or reported as not occurring / not applicable therefore there are no "not estimated" sectors.

Time series consistency was checked by verifying IEF changes and attention was paid to changes that increased 10% level. There are no such issues.

### 4.9.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

QA/QC check is performed with Tier1 method from IPCC GPG 2000.

Activity data used in NMVOC and $SO_2$ emissions was reported by CSB to LEGMC within National Inventory System. CSB has the internal QA/QC procedures based on mathematical model and analysis to avoid logic mistakes. The activity data used in estimations is repeatedly verified by CSB energy experts by checking the data input in data estimation database and reported in the NIR. All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, emission factors and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Emissions are checked using time series consistency check for the IEF estimated in CRF Reported and all IEF changes in time series are double-checked and reasonable explanation for IEF changes has to be found under each subsector source category description.

The QC form has been filled in for each category taking into account criteria given in QA/QC plan approved in national legislation. Form then is archived.

There was involved external auditor from CSB for QA/QC in 2016 mainly for comparing activity data with central statistics. No specific or significant issues were found under this sector.

### 4.9.5 Category-specific recalculations

No recalculations were done for this sector.

### 4.9.6 Category-specific planned improvements

No improvements are planned for this sector for nearest submissions.

# 5 AGRICULTURE (CRF 3)

## *5.1 OVERVIEW OF SECTOR*

Greenhouse gases (GHG) emissions from agriculture sector in Latvia include:

1) methane ($CH_4$) emissions from enteric fermentation of domestic livestock and manure management;
2) nitrous oxide ($N_2O$) emissions from manure management and managed soils;
3) carbon dioxide ($CO_2$) emissions from lime and urea application.

Emissions from managed soils include:

-) direct nitrous oxide emissions from:

1) application of synthetic nitrogen (N) fertilizer;
2) application of animal manure, compost, sewage sludge and other organic fertilizers;
3) urine and dung N deposited by grazing animals on pasture, range and paddock;
4) N in crop residues;
5) cultivation of organic soil in croplands and grasslands;
6) N mineralisation associated with loss of soil organic matter resulting from change of land use or management of mineral soils.

-) indirect nitrous oxide emissions from atmospheric deposition and nitrogen leaching/run-off.

Rice cultivation (3 C) and savannas (3 E) are not typical for Latvia, therefore these categories are reported as "NO" in CRF tables. Legislative measures and agricultural residue management practices prohibit agricultural residues burning on fields, therefore a notation key "NO" is used in CRF tables under the category Field Burning of Agricultural Residues (3 F). The calculation of emissions is based on 2006 IPCC Guidelines methodology. Detailed information about methods is provided under each subcategory. Overview of GHG emissions sources from Agriculture sector in 2014 is shown in Figure 5.1.

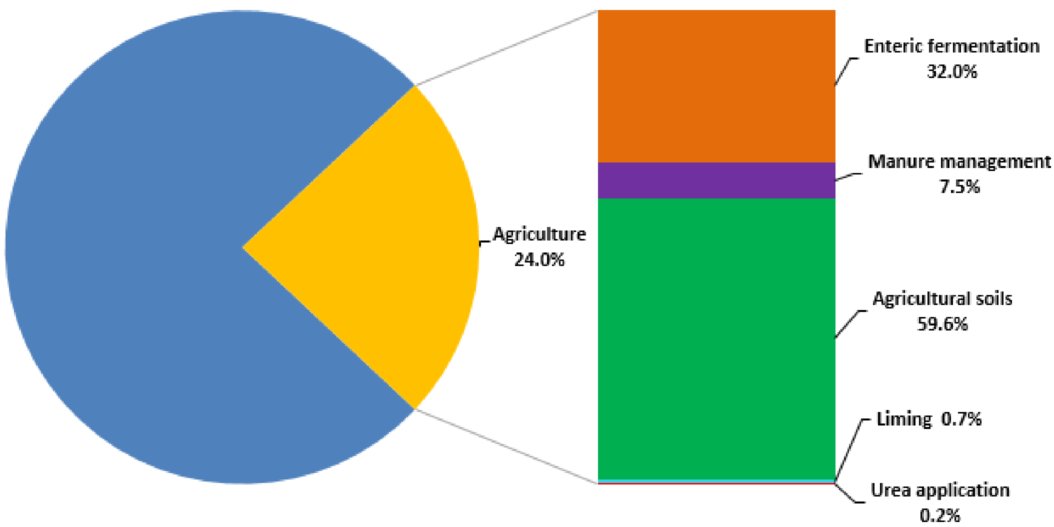


**Figure 5.1 Emissions from the agriculture sector compared with the total emissions in 2014**

In 2014, agriculture sector contributed 2726.4 kt $CO_2$ eq. which made up 24.0% of total national GHG emissions in Latvia. Agricultural soils are responsible for 59.6% of total emissions from Agriculture. Second largest emission source is Enteric fermentation contributing with 32%. Manure Management constituted 7.5% from Agicultural emissions in 2014. Liming and Urea application are less significant emission sources producing less then 1% of total Agricultural emissions in 2014 (Figure 5.1).

Nitrous oxide emissions constituted 63.4% (1729.8 kt $CO_2$ eq.) and methane emissions resulted in 35.7% (972.2 kt $CO_2$ eq.) of total GHG emissions from agricultural sector. Remaining 0.9% (24.4 kt $CO_2$) of total GHG emissions originated from liming and urea fertilization. 89.8% of total agriculture sector methane emissions resulted from enteric fermentation and 10.2% - from manure management. The largest part (94.0%) of total nitrous oxide emissions resulted from direct-indirect emissions of managed soils, only 6.0% of total nitrous oxide emissions related to manure management.

In 2014, GHG emissions from agriculture sector in Latvia increased by 3.3% comparing with 2013. However, annual emissions have been reduced by 50.0% since 1990 due to decrease in the number of livestock, nitrogen fertilizers etc. (Table 5.1).

**Table 5.1 Greenhouse gas emissions in the agricultural sector, 1990–2014 (kt $CO_2$ eq.)**

| Year | $CH_4$ | $N_2O$ | $CO_2$ | Total |
|---|---|---|---|---|
| **1990** | 2411.2 | 2663.7 | 379.1 | 5454.0 |
| **1991** | 2312.4 | 2495.7 | 238.6 | 5046.7 |
| **1992** | 1912.5 | 2010.7 | 37.5 | 3960.7 |
| **1993** | 1256.1 | 1609.9 | 4.0 | 2870.0 |
| **1994** | 1102.5 | 1464.2 | 2.5 | 2569.1 |
| **1995** | 1074.5 | 1326.0 | 2.0 | 2402.5 |
| **1996** | 1028.4 | 1343.5 | 1.5 | 2373.4 |
| **1997** | 1006.3 | 1352.5 | 1.3 | 2360.2 |
| **1998** | 936.4 | 1315.6 | 3.4 | 2255.5 |
| **1999** | 807.2 | 1253.0 | 3.5 | 2063.6 |
| **2000** | 811.7 | 1280.1 | 6.2 | 2098.0 |
| **2001** | 857.7 | 1361.5 | 2.2 | 2221.4 |
| **2002** | 849.7 | 1333.0 | 20.1 | 2202.9 |
| **2003** | 849.8 | 1378.9 | 27.1 | 2255.8 |
| **2004** | 822.5 | 1362.2 | 2.5 | 2187.3 |
| **2005** | 847.6 | 1420.2 | 3.0 | 2270.8 |
| **2006** | 854.6 | 1421.3 | 2.9 | 2278.8 |
| **2007** | 894.1 | 1473.8 | 6.5 | 2374.4 |
| **2008** | 868.3 | 1478.0 | 6.0 | 2352.3 |
| **2009** | 866.0 | 1510.6 | 8.5 | 2385.0 |
| **2010** | 873.9 | 1550.5 | 6.1 | 2430.5 |
| **2011** | 883.8 | 1560.1 | 12.5 | 2456.4 |
| **2012** | 903.3 | 1654.5 | 16.1 | 2573.9 |
| **2013** | 937.4 | 1684.5 | 17.9 | 2639.7 |
| **2014** | 972.2 | 1729.8 | 24.4 | 2726.4 |
| **Share of total % in 2014** | 35.7% | 63.4% | 0.9% | 100.0% |
| **2014 versus 2013** | +3.7% | +2.7% | +36.8% | +3.3% |
| **2014 versus 1990** | -59.7% | -35.1% | -93.6% | -50.0% |

**In all tables non-rounded values are used to calculate percentage*

Several emission sources in the Agriculture sector are key categories both in level and trend assessment. Information regarding results of key category analysis for the Agriculture sector is presented in Table 5.2**.**

**Table 5.2 Identified key categories for the agriculture sector**

| IPCC category | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | L1, L2,T1,T2 | X | X |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | L1,L2,T1,T2 | | X |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | L1,L2 | | X |
| 3.B.5 Indirect N2O emissions from Manure Management | $N_2O$ | L1,L2,T2 | X | X |
| 3.D.1. Direct N2O emissions from managed soils | $N_2O$ | L1, L2,T1,T2 | X | X |
| 3.G. Liming | $CO_2$ | T1,T2 | X | X |

Some interannual variation of emissions, which can be noticed from the time series, was mainly caused by fluctuation in activity data among the years due to changes in the number of animals, which had been significantly affected by economic situation in the country, as well as agricultural policy. Methane and nitrous oxide emissions from manure management were affected by the fluctuation in the number of animals and the proportion of manure managed in different manure management systems which vary depending on animal species. Nitrous oxide emissions from managed soils generally were affected by the numbers describing management of organic soils, amount of synthetic fertilizers consumption, the number of grazing livestock, sown area and crop yields, which have large variation among the years.

Emissions from agriculture noticeably decreased in the beginning of 1990s after the Soviet system and large state or collective farms collapses. However, in the recent years it is possible to observe a slight increase of sown area, consumption of synthetic N-fertilizers, non-dairy, sheep, swine and poultry numbers. State efforts to improve animal manure management systems (MMS) and expansion of anaerobic digestation in the largest farms is the main reason that reduces the increase of emissions from manure management. In the last years, dairy farming in Latvia turns to liquid slurry management system according to closing of small farms and reflection to the trend to this management system in developed countries, however liquid slurry produces more methane and results in increase of this type of emissions.

The number of cattle, sheep, swine, goats, horses, poultry, rabbits and fur-bearing animals' population, as well as data on milk production and fat content in milk are obtained from the Central Statistical Bureau (CSB) of Latvia Database[108] and statistical yearbooks[109]. The number of fur-bearing animals relates to no open access data. Similarly to the number of domestic livestock, also statistical information about amounts of synthetic fertilizer N application and crop production is obtained from the CSB database. The number of deer in

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[108] *Agriculture, Forestry and Fishery. http://data.csb.gov.lv/pxweb/en/lauks/?rxid=a79839fe-11ba-4ecd-8cc3-4035692c5fc8*
[109] *Agriculture in Latvia. Collection of Statistical Data. Rīga: 2014. 64 pp*

Latvia is obtained from available information from informative reports prepared by Ministry of Agriculture[110] and Wild Animal Breeders Association[111]. The distribution of different MMS is adopted from national studies. Calculation of the distribution is done based on research results and developed methodology provided by Latvia University of Agriculture.

Statistical information about livestock number in Latvia is included in Table 5.3. The number of fur-bearing animals is not available for 1990-1992 and 1995, therefore interpolation and extrapolation is used to fill in the gaps of time series.

**Table 5.3 Number of livestock, 1990–2014 (thousand heads)**

| Year | Dairy Cattle | Non-dairy Cattle | Sheep | Swine | Goats | Horses | Poultry | Rabbits | Fur-bearing animals | Deer |
|---|---|---|---|---|---|---|---|---|---|---|
| **1990** | 535.1 | 904.2 | 164.6 | 1401.1 | 5.4 | 30.9 | 10321.1 | 193.9 | 260.2 | ND |
| **1991** | 531.4 | 851.5 | 183.7 | 1246.5 | 6.1 | 30.0 | 10395.1 | 223.3 | 260.2 | ND |
| **1992** | 481.7 | 662.6 | 164.7 | 866.5 | 6.4 | 28.4 | 5438.3 | 198.5 | 260.2 | ND |
| **1993** | 351.0 | 326.9 | 114.0 | 481.8 | 6.3 | 26.2 | 4123.7 | 162.8 | 260.2 | ND |
| **1994** | 311.9 | 238.9 | 86.3 | 500.7 | 7.4 | 26.8 | 3699.6 | 154.5 | 221.0 | ND |
| **1995** | 291.9 | 245.2 | 72.2 | 552.8 | 8.9 | 27.2 | 4198.3 | 152.5 | 213.5 | ND |
| **1996** | 274.6 | 234.8 | 55.5 | 459.6 | 8.4 | 25.8 | 3790.7 | 134.3 | 205.9 | ND |
| **1997** | 262.8 | 214.1 | 40.7 | 429.9 | 8.9 | 23.3 | 3550.7 | 93.4 | 88.6 | ND |
| **1998** | 242.1 | 192.3 | 29.4 | 421.1 | 10.5 | 22.0 | 3208.8 | 97.6 | 55.2 | ND |
| **1999** | 205.6 | 172.8 | 27.0 | 404.9 | 8.1 | 19.0 | 3236.9 | 72.3 | 84.0 | ND |
| **2000** | 204.5 | 162.2 | 28.6 | 393.5 | 10.4 | 19.9 | 3104.6 | 110.9 | 97.2 | ND |
| **2001** | 209.1 | 175.6 | 29.0 | 428.7 | 11.5 | 19.6 | 3621.2 | 150.4 | 117.7 | ND |
| **2002** | 204.6 | 183.5 | 31.5 | 453.2 | 13.2 | 18.5 | 3882.0 | 141.6 | 116.3 | ND |
| **2003** | 186.3 | 192.3 | 39.2 | 444.4 | 15.0 | 15.4 | 4002.6 | 149.2 | 119.4 | ND |
| **2004** | 186.2 | 184.9 | 38.6 | 435.7 | 14.7 | 15.5 | 4049.5 | 135.5 | 143.5 | ND |
| **2005** | 185.2 | 200.0 | 41.6 | 427.9 | 14.9 | 13.9 | 4092.3 | 97.9 | 141.7 | ND |
| **2006** | 182.4 | 194.7 | 41.3 | 416.8 | 14.3 | 13.6 | 4488.1 | 92.9 | 182.8 | 3.3 |
| **2007** | 180.4 | 218.3 | 53.9 | 414.4 | 13.0 | 13.0 | 4756.8 | 96.4 | 181.4 | 4.0 |
| **2008** | 170.4 | 209.8 | 67.1 | 383.7 | 12.9 | 13.1 | 4620.5 | 57.4 | 197.5 | 5.3 |
| **2009** | 165.5 | 212.7 | 70.7 | 376.5 | 13.2 | 12.6 | 4828.9 | 43.9 | 164.4 | 7.8 |
| **2010** | 164.1 | 215.4 | 76.8 | 389.7 | 13.5 | 12.0 | 4948.7 | 33.5 | 167.0 | 7.6 |
| **2011** | 164.1 | 216.5 | 79.7 | 375.0 | 13.4 | 11.5 | 4417.9 | 39.3 | 183.7 | 9.6 |
| **2012** | 164.6 | 228.5 | 83.6 | 355.2 | 13.3 | 10.9 | 4910.9 | 37.3 | 231.6 | 9.3 |
| **2013** | 165.0 | 241.5 | 84.8 | 367.5 | 12.6 | 10.7 | 4985.8 | 38.9 | 231.6 | 11.5 |
| **2014** | 165.9 | 256.1 | 92.5 | 349.4 | 12.3 | 10.1 | 4413.9 | 38.3 | 313.9 | 13.2 |
| **2014 versus 2013*** | +0.5% | +6.0% | +9.1% | -4.9% | -2.4% | -5.6% | -11.5% | -1.5% | +35.5% | +14.2% |
| **2014 versus 1990*** | -69.0% | -71.7% | -43.8% | -75.1% | +127.8% | -67.3% | -57.2% | -80.2% | +20.6% | ND |

Latvian livestock industry has been influenced by historical events and economical situation. Particularly significant changes in the livestock industry began in 1992 after the restoration of Latvian independence when most of big farms went into liquidation. Since the Soviet

[110] *Ministry of Agriculture. Available at: https://www.zm.gov.lv/lauksaimnieciba/statiskas-lapas/lauksaimniecibas-gada-zinojumi?nid=531#jump*
[111] *Wild Animal Breeders Association. Available at: http://www.losp.lv/sites/default/files/articles/attachments/publications/22.12.2011_-_1500/17_savvalas_dzivnieki.pdf*

Union had a planned economy, most of the output of livestock products was carried out in other Soviet republics. Reorientation of livestock product export to Western markets was more difficult in terms of market saturation. Latvian farmers were forced to reduce production levels of milk, meat and crop. Consequently, livestock numbers declined most rapidly in 1990-1994 in all sectors, except for goat farming. All the above-mentioned social and economic changes lead to also eliminating of stud-farms. The horses were sold, only the strongest stud-farms continued to work. Starting from 2004, according to Latvia's accession to the European Union (EU), the number of livestock has stabilized. The increase of production indicators was characteristic for beef cattle, sheep, goat and poultry industries. Dairy farming is one of the most important branches of agriculture in Latvia. The number of dairy cows in Latvia is relatively stable, with a tendency to a slight increase in the last years. In 2014, 165.9 thousand dairy cows were registered and an average milk yield per cow reached 5512 kg, showing the highest value since 1990. Since 2009, the number of large farms has increased, while small farms have been closed, however dairy farms in Latvia are characterized by a low herd size in comparison with other European countries.

Statistical surveys are the source of data on crop production in commercial companies, private farms and individual merchants. Fluctuations in activity data is observed due to economic situation in the country. Since 2007, two sugar factories have stopped their activity therefore no data is presented further. Agricultural statistics data fulfil criteria determined by the EU and requirements are determined in the legislative acts. The Project Documentation System (ADS) is established at CSB. It is a quality metadata system for internal and external users. There are methodological descriptions of all statistical surveys and calculations. Annual samples are made up as stratified simple samples. Holdings are selected by economic size (standard output – SO) and type of farming. SO is a standard indicator characterizing the economic activity of agricultural holding, i.e., value acquired from one hectare of agricultural crops or one livestock head (unit), estimated at prices of the corresponding region and expressed in EUR. A total standard output characterises the economic size of the holding in monetary terms. Farms with SO >= 50000 EUR are included for 100% statistical surveys; farms with 2000 EUR <SO < 50000 EUR are selected by economic size and type of farming. Sample size for annual sample (Crop and Animal survey) includes 5.1 thousand holdings. Small holdings with SO < 2000 EUR are not included in annual Crop and Animal surveys, but information for these holdings is estimated using experts' method. For this estimation CSB uses information from Agricultural Censuses and surveys of small farms, which are organized between Censuses. Crop and livestock statistics quality reports are available on CSB web page[112;113].

Total sown area in 2014 was 1150.5 thousand ha, the number of total sown area increased by 0.3% compared to 2013. Share of main crops in the total sown area is represented in Figure 5.2.

[112] *Available at: http://www.csb.gov.lv/sites/default/files/quality_report_on_annual_crop_statistics_2010_0.pdf*
[113] *Available at: http://www.csb.gov.lv/sites/default/files/quality_report_on_livestock_and_meat_statistics_2010_0.pdf*

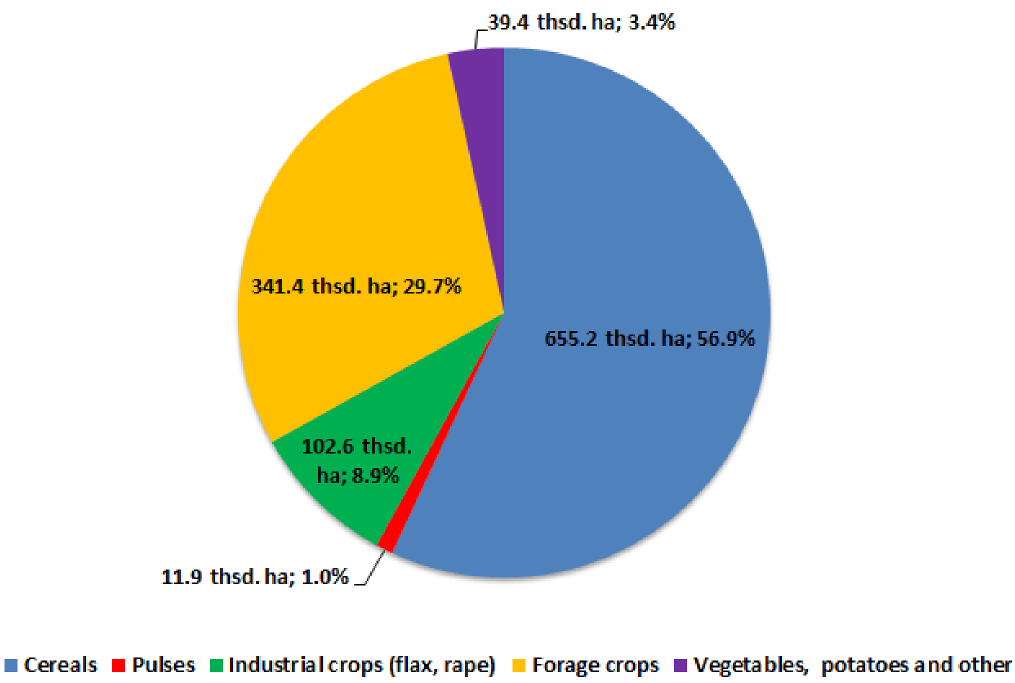


**Figure 5.2 Sown area in Latvia, 2014**

Statistical information about crop production in Latvia for calculation of nitrous oxide emissions is included in Table 5.4 and Table 5.5. Data about sown area of oil flax (1990-1999) are not available; therefore data for filling gaps in the time series are extrapolated from the closest numbers. Other statistical data are included in relevant subchapters.

**Table 5.4 Sown area of agricultural crops, 1990–2014 (thousand ha)**

| Year | Wheat | Barley | Triticale | Oats | Rye | Buckwheat | Mixed cereals | Pulses |
|---|---|---|---|---|---|---|---|---|
| **1990** | 141.5 | 306.6 | 1.1 | 82.4 | 130.7 | 0.1 | 12.7 | 10.5 |
| **1991** | 71.5 | 397.4 | 2.6 | 92.7 | 69.2 | 0.1 | 13.7 | 9.0 |
| **1992** | 128.6 | 347.0 | 3.3 | 69.4 | 131.4 | 0.1 | 13.5 | 6.7 |
| **1993** | 169.1 | 270.3 | 6.8 | 48.5 | 187.6 | 0.1 | 6.2 | 2.8 |
| **1994** | 94.6 | 264.1 | 3.1 | 54.0 | 62.7 | 0.1 | 5.3 | 2.8 |
| **1995** | 109.6 | 195.9 | 2.7 | 45.6 | 40.4 | 0.1 | 6.8 | 3.0 |
| **1996** | 149.2 | 176.4 | 1.7 | 53.6 | 56.4 | 0.1 | 6.8 | 3.6 |
| **1997** | 152.3 | 188.7 | 2.8 | 59.1 | 62.5 | 0.6 | 11.0 | 4.7 |
| **1998** | 150.9 | 165.9 | 5.3 | 59.7 | 57.7 | 1.7 | 13.6 | 6.8 |
| **1999** | 146.0 | 142.7 | 5.8 | 47.2 | 47.2 | 2.3 | 7.9 | 2.5 |
| **2000** | 158.1 | 130.6 | 5.9 | 45.5 | 54.8 | 6.2 | 5.3 | 2.1 |
| **2001** | 166.8 | 124.0 | 13.0 | 55.2 | 55.8 | 10.6 | 4.1 | 3.2 |
| **2002** | 153.5 | 132.1 | 15.5 | 47.1 | 42.3 | 10.5 | 3.4 | 2.5 |
| **2003** | 167.8 | 129.2 | 19.1 | 49.4 | 44.2 | 6.5 | 2.9 | 2.9 |
| **2004** | 169.9 | 123.5 | 17.1 | 56.7 | 45.1 | 9.7 | 3.3 | 2.6 |
| **2005** | 187.4 | 145.9 | 13.3 | 58.0 | 39.3 | 10.4 | 3.7 | 2.2 |
| **2006** | 215.1 | 149.8 | 11.3 | 62.9 | 42.8 | 14.0 | 4.9 | 1.4 |
| **2007** | 224.6 | 139.7 | 12.4 | 62.4 | 57.5 | 10.7 | 3.0 | 1.6 |
| **2008** | 256.6 | 123.9 | 13.8 | 66.2 | 59.0 | 10.4 | 2.7 | 1.6 |
| **2009** | 285.7 | 94.6 | 13.1 | 60.6 | 59.0 | 10.1 | 2.5 | 2.5 |
| **2010** | 307.6 | 91.1 | 12.1 | 63.3 | 34.6 | 8.2 | 3.6 | 2.7 |
| **2011** | 311.3 | 94.7 | 9.9 | 59.3 | 28.4 | 9.5 | 3.8 | 3.8 |
| **2012** | 354.7 | 85.2 | 13.3 | 62.0 | 37 | 11.7 | 3.8 | 4.6 |

| Year | Wheat | Barley | Triticale | Oats | Rye | Buckwheat | Mixed cereals | Pulses |
|---|---|---|---|---|---|---|---|---|
| **2013** | 371.8 | 82.3 | 14.2 | 62.4 | 29.1 | 10.6 | 1.2 | 7.0 |
| **2014** | 402.5 | 119.9 | 10.7 | 66.8 | 32.3 | 10.2 | 4.6 | 11.9 |
| **2014 versus 2013** | +8.3% | +45.7% | -24.6% | +7.1% | +11.0% | -3.8% | +283.3% | +70.0% |
| **2014 versus 1990** | +184.5% | -60.9% | +872.7% | -18.9% | -75.3% | +10100.0% | -63.8% | +13.3% |

**Table 5.5 Sown area of agricultural crops, 1990–2014 (thousand ha)**

| Year | Sugar beet | Fodder roots | Potatoes | Maize for silage and forage | Crops for green feed and silage | Perennial grass | Fibre flax | Oil flax | Rape |
|---|---|---|---|---|---|---|---|---|---|
| **1990** | 14.7 | 37.0 | 80.3 | 44.8 | 73.9 | 664.0 | 11.9 | 0.3 | 1.9 |
| **1991** | 14.6 | 39.4 | 82.2 | 39.5 | 84.9 | 679.6 | 8.8 | 0.3 | 0.7 |
| **1992** | 24.8 | 36.5 | 96.9 | 24.8 | 56.7 | 598.6 | 7.6 | 0.3 | 1.3 |
| **1993** | 12.1 | 29.6 | 87.7 | 9.2 | 31.4 | 536.0 | 0.6 | 0.3 | 1.7 |
| **1994** | 12.0 | 26.2 | 80.4 | 2.7 | 20.9 | 540.6 | 1.5 | 0.3 | 2.2 |
| **1995** | 9.5 | 19.8 | 75.3 | 0.6 | 17.8 | 374.7 | 1.4 | 0.3 | 1.1 |
| **1996** | 10.0 | 17.3 | 78.7 | 1.2 | 11.6 | 398.4 | 1.3 | 0.3 | 0.8 |
| **1997** | 10.9 | 14.9 | 69.6 | 0.5 | 13.2 | 389.7 | 1.6 | 0.3 | 0.4 |
| **1998** | 16.3 | 13.1 | 58.8 | 0.5 | 12.8 | 392.7 | 2.2 | 0.3 | 1.2 |
| **1999** | 15.5 | 9.1 | 50.1 | 0.7 | 12.0 | 383.1 | 2.0 | 0.3 | 6.5 |
| **2000** | 12.7 | 9.0 | 51.3 | 1.2 | 11.4 | 347.2 | 1.6 | 0.3 | 6.9 |
| **2001** | 14.1 | 9.6 | 55.1 | 1.0 | 8.4 | 304.4 | 1.4 | 0.4 | 8.4 |
| **2002** | 15.9 | 7.5 | 53.6 | 1.2 | 7.2 | 335.1 | 2.1 | 0.1 | 18.4 |
| **2003** | 14.4 | 7.1 | 54.6 | 1.7 | 9.9 | 282.9 | 2.1 | 0.1 | 25.9 |
| **2004** | 13.8 | 5.6 | 48.9 | 2.9 | 9.9 | 302.3 | 2.7 | 0.1 | 54.3 |
| **2005** | 13.5 | 3.8 | 45.1 | 2.9 | 8.7 | 360.6 | 2.2 | 0.2 | 71.4 |
| **2006** | 12.7 | 2.8 | 45.1 | 3.5 | 11.4 | 425.8 | 1.5 | 0.2 | 83.2 |
| **2007** | 0.3 | 2.3 | 40.3 | 5.1 | 11.1 | 427.1 | 1.4 | 0.1 | 99.2 |
| **2008** | NO | 0.9 | 37.8 | 5.9 | 8.2 | 413.1 | 0.4 | 0.2 | 82.6 |
| **2009** | NO | 0.7 | 30 | 9.8 | 7.2 | 413.7 | 0.1 | 0.2 | 93.3 |
| **2010** | NO | 0.9 | 30.1 | 7.1 | 6.3 | 387.3 | 0.0 | 1.1 | 110.6 |
| **2011** | NO | 0.8 | 29.7 | 11.3 | 5.7 | 370.8 | 0.1 | 1.4 | 121.3 |
| **2012** | NO | 0.6 | 28.2 | 20.6 | 10.6 | 351.4 | 0.6 | 0.3 | 117.5 |
| **2013** | NO | 0.3 | 27.3 | 20.4 | 7.7 | 356.7 | 0.2 | 0.1 | 128.2 |
| **2014** | NO | 0.2 | 26.8 | 21.7 | 7.3 | 312.4 | 0.1 | 0.5 | 100.1 |
| **2014 versus 2013** | NO | -33.3% | -1.8% | +6.4% | -5.2% | -12.4% | -50.0% | +400.0% | -21.9% |
| **2014 versus 1990** | -100.0% | -99.5% | -66.6% | -51.6% | -90.1% | -53.0% | -99.2% | +66.7% | 5168.4% |

## *5.2 ENTERIC FERMENTATION (CRF 3.A)*

### 5.2.1 Category description

Methane ($CH_4$) is emitted as a by-product of the normal livestock digestive process, in which microbes resident in the animals' digestive system ferment the feed consumed by the animal. This fermentation process is also known as enteric fermentation[114]. Ruminant livestock (cattle, sheep and goats) are the primary source of methane emissions. The amount of enteric methane emitted is driven primarily by the number and size of domestic animals, the type of digestive system, and the type and amount of feed consumed[115]. Latvia reports emissions from cattle (including dairy cows, other mature non-dairy cattle and growing cattle according to CRF Option B), sheep, swine, goats, horses, rabbits, and fur-bearing animals (Table 5.6). Emission from poultry enteric fermentation has not been estimated. According to 2006 IPCC Guidelines, methodology for enteric fermentation calculation from poultry is not developed. Methane emission from poultry is calculated only in the manure management category.

**Table 5.6 Reported emissions under the subcategory enteric fermentation**

| CRF | Source | Emissions reported | Level |
|---|---|---|---|
| 3.A 1 | Dairy Cattle / Non-dairy Cattle (other mature and growing cattle) | $CH_4$ | Tier 2 |
| 3.A 2 | Sheep | $CH_4$ | Tier 1 |
| 3.A 3 | Swine | $CH_4$ | Tier 1 |
| 3.A 4 | Other – Buffalo | NO | Tier 1 |
| 3.A 4 | Other – Camels | NO | Tier 1 |
| 3.A 4 | Other – Deer | $CH_4$ | Tier 1 |
| 3.A 4 | Other – Goats | $CH_4$ | Tier 1 |
| 3.A 4 | Other – Horses | $CH_4$ | Tier 1 |
| 3.A 4 | Other – Mules and asses | NO | Tier 1 |
| 3.A 4 | Other – Poultry | NE | Tier 1 |
| 3.A 4 | Other – Rabbits | $CH_4$ | Tier 1 |
| 3.A 4 | Other – Fur-bearing animals | $CH_4$ | Tier 1 |

Cattle are the largest source of enteric fermentation methane emissions (94.9% from total enteric fermentation methane emissions) in Latvia. In 2014, dairy cattle produced 64.6% and non-dairy cattle –30.3% of methane emissions. Emissions from sheep formed 2.1%, from swine – 1.5% and from other livestock – 1.5% of the total emissions from enteric fermentation. In 2014, total methane emissions from enteric fermentation of domestic livestock increased by 1.18 kt or 3.5%, compared with 2013. This is caused by the increase of the number of cattle, sheep, fur-bearing animals and deer. Since 1990, generally due to the evident fall of the number of livestock, methane emissions decreased by 60.7% (Table 5.7).

**Table 5.7 Methane emissions from enteric fermentation by livestock category, 1990–2014 (kt)**

| Year | Dairy cattle | Non-Dairy cattle | Sheep | Swine | Goats | Horses | Rabbits | Fur-bearing animals | Deer | Total, $CH_4$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **1990** | 55.11 | 29.61 | 1.32 | 2.10 | 0.03 | 0.56 | 0.11 | 0.03 | ND | 88.86 |
| **1991** | 53.48 | 27.70 | 1.47 | 1.87 | 0.03 | 0.54 | 0.13 | 0.03 | ND | 85.25 |
| **1992** | 46.26 | 21.06 | 1.32 | 1.30 | 0.03 | 0.51 | 0.12 | 0.03 | ND | 70.62 |
| **1993** | 33.61 | 10.36 | 0.91 | 0.72 | 0.03 | 0.47 | 0.10 | 0.03 | ND | 46.23 |
| **1994** | 30.70 | 7.64 | 0.69 | 0.75 | 0.04 | 0.48 | 0.09 | 0.02 | ND | 40.42 |
| **1995** | 29.41 | 7.69 | 0.58 | 0.83 | 0.04 | 0.49 | 0.09 | 0.02 | ND | 39.16 |

[114] *IPCC GPG, 2000*
[115] *2006 IPCC Guidelines*

| Year | Dairy cattle | Non-Dairy cattle | Sheep | Swine | Goats | Horses | Rabbits | Fur-bearing animals | Deer | Total, $CH_4$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **1996** | 28.36 | 7.57 | 0.44 | 0.69 | 0.04 | 0.46 | 0.08 | 0.02 | ND | 37.67 |
| **1997** | 28.45 | 6.89 | 0.33 | 0.64 | 0.04 | 0.42 | 0.06 | 0.01 | ND | 36.83 |
| **1998** | 26.63 | 6.18 | 0.24 | 0.63 | 0.05 | 0.40 | 0.06 | 0.01 | ND | 34.18 |
| **1999** | 22.59 | 5.40 | 0.22 | 0.61 | 0.04 | 0.34 | 0.04 | 0.01 | ND | 29.24 |
| **2000** | 23.03 | 4.99 | 0.23 | 0.59 | 0.05 | 0.36 | 0.07 | 0.01 | ND | 29.33 |
| **2001** | 23.97 | 5.34 | 0.23 | 0.64 | 0.06 | 0.35 | 0.09 | 0.01 | ND | 30.69 |
| **2002** | 23.19 | 5.65 | 0.25 | 0.68 | 0.07 | 0.33 | 0.08 | 0.01 | ND | 30.26 |
| **2003** | 22.63 | 6.17 | 0.31 | 0.67 | 0.08 | 0.28 | 0.09 | 0.01 | ND | 30.24 |
| **2004** | 21.93 | 5.87 | 0.31 | 0.65 | 0.07 | 0.28 | 0.08 | 0.01 | ND | 29.21 |
| **2005** | 22.19 | 6.54 | 0.33 | 0.64 | 0.07 | 0.25 | 0.06 | 0.01 | ND | 30.11 |
| **2006** | 22.26 | 6.61 | 0.33 | 0.63 | 0.07 | 0.24 | 0.05 | 0.02 | 0.06 | 30.27 |
| **2007** | 22.42 | 7.71 | 0.43 | 0.62 | 0.07 | 0.23 | 0.06 | 0.02 | 0.07 | 31.63 |
| **2008** | 21.57 | 7.52 | 0.54 | 0.58 | 0.06 | 0.24 | 0.03 | 0.02 | 0.09 | 30.65 |
| **2009** | 21.13 | 7.81 | 0.57 | 0.56 | 0.07 | 0.23 | 0.03 | 0.02 | 0.13 | 30.53 |
| **2010** | 21.15 | 8.15 | 0.61 | 0.58 | 0.07 | 0.22 | 0.02 | 0.02 | 0.13 | 30.95 |
| **2011** | 21.26 | 8.39 | 0.64 | 0.56 | 0.07 | 0.21 | 0.02 | 0.02 | 0.16 | 31.32 |
| **2012** | 21.64 | 9.04 | 0.67 | 0.53 | 0.07 | 0.20 | 0.02 | 0.02 | 0.16 | 32.34 |
| **2013** | 22.12 | 9.87 | 0.68 | 0.55 | 0.06 | 0.19 | 0.02 | 0.02 | 0.20 | 33.72 |
| **2014** | 22.54 | 10.58 | 0.74 | 0.52 | 0.06 | 0.18 | 0.02 | 0.03 | 0.22 | 34.91 |
| **Share of total % in 2014** | 64.6% | 30.3% | 2.1% | 1.5% | 0.2% | 0.5% | 0.1% | 0.1% | 0.6% | 100% |
| **2014 versus 2013** | +1.9% | +7.2% | +9.1% | -4.9% | -2.4% | -5.6% | -1.5% | +35.5% | +14.2% | +3.5% |
| **2014 versus 1990** | -59.1% | -64.3% | -43.8% | -75.1% | +127.8% | -67.3% | -80.2% | +20.6% | ND | -60.7% |

### 5.2.2 Methodological issues

The Tier 1 approach relies on default emissions factors. For Tier 1 methodology countries are required to collect data on number of animals for each livestock category. The Tier 2 approach is more complex because it draws upon country-specific information on animal and feed characteristics. The Tier 2 approach is recommended to estimate methane emissions for countries with large cattle and sheep populations.

Emissions from enteric fermentation of domestic livestock in Latvia have been calculated by using the IPCC Tier 1 and Tier 2 methodologies presented in the 2006 IPCC Guidelines. Methane emissions from enteric fermentation for sheep, swine, goats, horses, rabbits, fur-bearing animals and deer have been calculated with the IPCC Tier 1 methodology by multiplying the number of the animals in each category with the IPCC default emission factor of the respective livestock category as shown in 2006 IPCC Guidelines[116]:

$$Emissions = EF_{(T)} \cdot \left(\frac{N_{(T)}}{10^6}\right)$$

*where:*
*Emissions = methane emissions from Enteric Fermentation, kt* $CH_4$ *yr*$^{-1}$

[116] *2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.19, page 10.28*

*$EF_{(T)}$ = emission factor for the defined livestock population, kg $CH_4$ head$^{-1}$ yr$^{-1}$*
*$N_{(T)}$ = the number of head of livestock species / category T in the country*
*T = species/category of livestock*

The default emission factors as for developed countries according to 2006 IPCC Guidelines[117] were used to calculate methane emissions from enteric fermentation for sheep, swine, goats, horses and rabbits (Table 5.8). As default IPCC and national emission factors for rabbits and fur-bearing animals are not available, other emission factors as Norwegian[118] emission factor for fur-bearing animals and Russian[119] emission factor for rabbits were used for enteric fermentation emission calculations similarly by experience of the neighbouring countries. Emission factor for deer also is adopted form Norwegian National Inventory as average value reported for deer and reindeer, because in the data base of Agricultural data centre category deer includes also the information about reindeer. For reindeer the emission factor 14.0 kg animal$^{-1}$ year$^{-1}$ is used and for deer 20.0 kg animal$^{-1}$ year$^{-1}$ in Norwegian National Inventory Report based on studies of Karlengen (2012)[120].

**Table 5.8 Default methane emission factors from enteric fermentation**

| Livestock category | EF (kg $CH_4$ head$^{-1}$ yr$^{-1}$) |
|---|---|
| Sheep | 8.00 |
| Swine | 1.50 |
| Goats | 5.00 |
| Horses | 18.00 |
| Rabbits | 0.59 |
| Fur-bearing animals | 0.10 |
| Deer | 17.0 |

The Tier 2 approach to estimate emissions is implemented for cattle, because emissions from cattle make up the biggest part of total agricultural sector methane emissions. With the Tier 2 methodology methane emissions have been calculated as in the Tier 1 methodology mentioned above, but the emission factors (EF) for dairy cattle and young and mature non-dairy cattle have been calculated according to 2006 IPCC Guidelines methodology represented as[121]:

$$EF = \left[\frac{GE \cdot \left(\frac{Y_m}{100}\right) \cdot 365}{55.65}\right]$$

*where:*
*EF = emission factor, kg $CH_4$ head$^{-1}$ yr$^{-1}$*
*GE = gross energy intake, MJ head$^{-1}$ day$^{-1}$*
*$Y_m$ = methane conversion factor, per cent of gross energy in feed converted to methane (default values in table 10.12, page 10.30 from 2006 IPCC Guidelines)*
*The factor 55.65 (MJ/kg $CH_4$) is the energy content of methane*

*[117] 2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.10, page 10.28*
*[118] Greenhouse gas emission in Norway 1990-2011, National inventory report, 2013, p. 238, Table 6.3*
*[119] Национальный доклад о кадастре антропогенных выбросов из источников и абсорбции поглотителями парниковых газов не регулируемых Монреальским протоколом за 1990-2011 г. Москва, 2013. Часть 1, С. 175, Таблица 6.5*
*[120] Karlengen, I. J., Svihus, B., Kjos, N. P. & Harstad, O. M. (2012): Husdyrgjødsel; oppdatering avmengder gjødsel og utskillelse av nitrogen, fosfor og kalium. Sluttrapport. (Manure; anupdate of amounts of manure and excretion of nitrogen, phosphorus and potassium. Final report). Ås: Departement of Animal and Aquacultural Sciences, Norwegian University of LifeSciences (Institutt for husdyr- og akvakulturvitenskap, NMBU-Norges miljø- ogbiovitenskapelige universitet)*
*[121] 2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.21, page 10.31*

For cattle, the gross energy intake (GE) has been calculated according to 2006 IPCC Guidelines[122]:

$$GE = \left[ \frac{\left( \frac{NE_m + NE_a + NE_1 + NE_{work} + NE_p}{REM} \right) + \left( \frac{NE_g}{REG} \right)}{\frac{DE\%}{100}} \right]$$

where:

*GE = gross energy, MJ day$^{-1}$*
*$NE_m$ = net energy required by the animal for maintenance, MJ day$^{-1}$*
*$NE_a$ = net energy for animal activity, MJ day$^{-1}$*
*$NE_l$ = net energy for lactation, MJ day$^{-1}$*
*$NE_{work}$ = net energy for work, MJ day$^{-1}$*
*$NE_p$ = net energy required for pregnancy, MJ day$^{-1}$*
*REM = ratio of net energy available in a diet for maintenance to digestible energy consumed*
*NEg = net energy needed for growth, MJ day$^{-1}$*
*REG = ratio of net energy available for growth in a diet to digestible energy consumed*
*DE%= digestible energy expressed as a percentage of gross energy*

The equations for calculating $NE_m$ (Equation 10.3, 2006 IPCC Guidelines), $NE_a$ (Equation 10.4, 2006 IPCC Guidelines), $NE_l$ (Equation 10.8, 2006 IPCC Guidelines), $NE_p$ (Equation 10.13, 2006 IPCC Guidelines), $NE_g$ (Equation 10.6, 2006 IPCC Guidelines), REM (Equation 10.14, 2006 IPCC Guidelines) and REG (Equation 10.15, 2006 IPCC Guidelines)[123] are:

$$NE_m = Cf_i \cdot (Weight)^{0.75}$$

$$NE_a = C_a \cdot NE_m$$

$$NE_l = Milk \cdot (1.47 + 0.40 \cdot Fat)$$

$$NE_p = C_{pregnancy} \cdot NE_m$$

$$NE_g = 22.02 \cdot \frac{BW}{C \cdot MW}^{0.75} \cdot WG^{1.097}$$

$$REM = \left[1.123 - (4.092 \cdot 10^{-3} \cdot DE\%) + [1.126 \cdot 10^{-5} \cdot (DE\%)^2] - \left(\frac{25.4}{DE\%}\right)\right]$$

$$REG = \left[1.164 - (5.160 \cdot 10^{-3} \cdot DE\%) + [1.308 \cdot 10^{-5} \cdot (DE\%)^2] - \left(\frac{37.4}{DE\%}\right)\right]$$

where:

*$Cf_i$ = maintenance coefficient (default values used[124])*
*Weight = animal weight, kg*
*Ca = coefficient corresponding to animals feeding situation (default values used)[125]*
*Milk = amount of milk produced, kg of milk day$^{-1}$*
*Fat = fat content of milk, % by weight*
*$C_{pregnancy}$ = Pregnancy coefficient (default values used[126])*
*BW = the average live body weight (BW) of the animals in the population, kg*
*MW = the mature live body weight of an adult female in moderate body condition, kg*
*WG = the average daily weight gain of the animals in the population, kg day$^{-1}$*
*C = a coefficient with a value of 0.8 for females, 1.0 for castrates and 1.2 for bulls*
*REM = ratio of net energy available in a diet for maintenance to digestible energy consumed*
*REG= ratio of net energy available for growth in a diet to digestible energy consumed*
*DE% = digestible energy, %*

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[122] *2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.16, page 10.21*
[123] *2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.3-10.15, page 10.15-10.21*
[124] *2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.4, page 10.16*
[125] *2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.5, page 10.17*
[126] *2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.7, page 10.20*

When using NEp to calculate GE, the NEp estimate must be weighted by the portion of the mature females that actually go through gestation in a year. According to animal breeding specialist calculations based on data of Agricultural Data Centre Republic of Latvia Register, 83% of the NEp value for dairy cattle is used in the GE equation.

Methane conversion factor (Ym) of zero is assumed for juveniles consuming only milk (2006 IPCC Guidelines, p.10.30). In Latvia, it was supposed that calves feed milk and milk substitute no longer than of age 3 months. Therefore it was assumed that methane conversion rate of young growing cattle group (under 1 year old) is 5.5% in 2014. The rate was estimated from IPCC default Ym 6.5%, based on an assumption that for calves between 0 and 3 months Ym is 0%.

Feed digestibility (DE) 65% is used in calculations according to the average value represented in Table 10.2 in the 2006 IPCC Guidelines, because detailed information on feed digestibility are not available in the country yet.

The calculation of GE for dairy cattle is strongly based on the milk production and fat content in milk. Trends about milk production and fat content in milk are presented in Table 5.9. Values of milk fat content for 1990-1997 are derived by extrapolation based on an assumption that fat content in milk was around 3.5% in 1990; all other information comes from CSB of Latvia.

**Table 5.9 Average milk yield per cow and fat content**

| Year | Average milk yield, kg year$^{-1}$ | Fat content, % |
|---|---|---|
| **1990** | 3437 | 3.50 |
| **1991** | 3205 | 3.58 |
| **1992** | 2793 | 3.67 |
| **1993** | 2741 | 3.75 |
| **1994** | 2923 | 3.84 |
| **1995** | 3074 | 3.92 |
| **1996** | 3237 | 4.01 |
| **1997** | 3585 | 4.09 |
| **1998** | 3733 | 4.06 |
| **1999** | 3754 | 4.00 |
| **2000** | 3898 | 4.08 |
| **2001** | 4055 | 4.08 |
| **2002** | 3958 | 4.08 |
| **2003** | 4261 | 4.11 |
| **2004** | 4251 | 4.17 |
| **2005** | 4364 | 4.25 |
| **2006** | 4492 | 4.26 |
| **2007** | 4636 | 4.31 |
| **2008** | 4822 | 4.29 |
| **2009** | 4892 | 4.31 |
| **2010** | 4998 | 4.29 |
| **2011** | 5064 | 4.22 |
| **2012** | 5250 | 4.16 |
| **2013** | 5508 | 4.08 |
| **2014** | 5812 | 3.86 |
| **2014 versus 2013** | +5.5% | -5.4% |
| **2014 versus 1990** | +69.1% | +10.3% |

In Latvian inventory livestock category *Cattle* (CRF 3.A.1) is reported in three sub-categories: mature dairy cattle, other mature cattle and growing cattle. Calculations of methane emission from enteric fermentation for dairy cattle are not divided into smaller sub-groups. Estimation of methane emissions from non-dairy cattle is split in seven age and production type sub-groups according to the records in the database of CSB of Latvia. Growing cattle group is represented by young cattle under 1 year and young cattle aged from 1 to 2 years. These two growing cattle groups are segregated for dairy and beef cattle. Other mature cattle group include bulls, heifers and other cows aged over 2 years old. The numbers of non-dairy cattle by sub-categories are presented in Table 5.10.

Missing data or no available data for 1990-1995 are created by linear extrapolation. Total numbers of young cattle under 1 year and aged 1 to 2 years are provided by CSB. Data of young dairy and beef cattle are calculated by Latvia University of Agriculture experts based on CSB totals of mentioned young cattle groups. All numbers of other mature cattle over 2 years are original data obtained from CSB data base.

**Table 5.10 The number of non-dairy cattle by sub-categories in Latvia, 1990-2014 (thousand heads)**

| Year | Growing Cattle | | | | | | Other Mature Cattle | | |
|---|---|---|---|---|---|---|---|---|---|
| | Young cattle under 1 year | | | Young cattle aged from 1 to 2 years | | | Mature non-dairy cattle over 2 years | | |
| | dairy cattle calves | beef cattle calves | total | dairy cattle | beef cattle | total | bulls | heifers | other cows |
| **1990** | 267.6 | 257.7 | 525.2 | 214.0 | 88.6 | 302.6 | 12.0 | 54.3 | 10.1 |
| **1991** | 265.7 | 228.9 | 494.6 | 212.6 | 72.4 | 285.0 | 11.3 | 51.2 | 9.6 |
| **1992** | 240.9 | 144.1 | 384.9 | 192.7 | 29.0 | 221.7 | 8.8 | 39.8 | 7.4 |
| **1993** | 140.4 | 49.5 | 189.9 | 87.8 | 21.7 | 109.4 | 4.3 | 19.6 | 3.7 |
| **1994** | 93.6 | 45.2 | 138.8 | 62.4 | 17.5 | 79.9 | 3.2 | 14.4 | 2.7 |
| **1995** | 87.6 | 47.2 | 134.8 | 64.2 | 17.8 | 82.0 | 3.2 | 14.7 | 2.8 |
| **1996** | 96.1 | 38.3 | 134.4 | 60.4 | 18.9 | 79.3 | 3.3 | 15.0 | 2.8 |
| **1997** | 92.0 | 31.7 | 123.7 | 52.6 | 18.1 | 70.7 | 2.6 | 13.8 | 3.3 |
| **1998** | 84.7 | 24.6 | 109.3 | 48.4 | 17.5 | 65.9 | 1.6 | 12.7 | 2.8 |
| **1999** | 82.2 | 18.4 | 100.6 | 45.2 | 14.3 | 59.5 | 1.1 | 9.5 | 2.1 |
| **2000** | 75.7 | 22.2 | 97.9 | 40.9 | 10.7 | 51.6 | 0.8 | 9.8 | 2.1 |
| **2001** | 83.6 | 28.4 | 112.0 | 37.6 | 11.4 | 49.0 | 1.7 | 10.4 | 2.5 |
| **2002** | 92.1 | 18.6 | 110.7 | 45.0 | 15.3 | 60.3 | 1.1 | 8.7 | 2.7 |
| **2003** | 93.2 | 16.0 | 109.1 | 48.4 | 18.3 | 66.7 | 1.5 | 11.2 | 3.8 |
| **2004** | 93.1 | 17.3 | 110.4 | 41.0 | 15.6 | 56.6 | 1.7 | 11.6 | 4.6 |
| **2005** | 92.6 | 26.3 | 118.9 | 42.6 | 17.0 | 59.6 | 1.6 | 11.9 | 8.0 |
| **2006** | 91.2 | 16.3 | 107.5 | 47.4 | 15.5 | 62.9 | 1.8 | 13.1 | 9.5 |
| **2007** | 90.2 | 24.7 | 114.9 | 59.5 | 13.0 | 72.5 | 1.2 | 14.6 | 15.2 |
| **2008** | 85.2 | 23.2 | 108.4 | 56.2 | 10.0 | 66.2 | 2.6 | 20.8 | 12.7 |
| **2009** | 82.8 | 24.8 | 107.4 | 54.6 | 12.2 | 66.8 | 3.0 | 19.9 | 15.5 |
| **2010** | 82.1 | 23.6 | 105.6 | 54.2 | 13.4 | 67.6 | 3.2 | 20.3 | 18.7 |
| **2011** | 82.1 | 21.9 | 103.9 | 54.2 | 12.5 | 66.7 | 3.1 | 20.9 | 22.0 |
| **2012** | 82.3 | 26.1 | 108.4 | 54.3 | 15.7 | 70.0 | 3.5 | 21.0 | 25.6 |
| **2013** | 82.5 | 26.8 | 109.3 | 54.5 | 20.9 | 75.3 | 4.3 | 23.4 | 29.2 |
| **2014** | 83.0 | 35.5 | 118.4 | 54.7 | 20.2 | 74.9 | 4.4 | 24.3 | 34.2 |
| **2014 versus 2013** | - | - | +8.3% | - | - | -0.5% | +2.3% | +3.8% | +17.1% |
| **2014 versus 1990** | - | - | -77.5% | - | - | -75.2% | -63.3% | -55.2% | +238.6% |

Results of gross energy intake (GE) calculation for dairy and non-dairy cattle from enteric fermentation are summarized in Table 5.11.

**Table 5.11 Average gross energy (GE) intake (MJ $day^{-1}$) and methane emission factors (EF) from Enteric Fermentation (kg $CH_4$ $head^{-1}$ $year^{-1}$) and cattle weight (kg $head^{-1}$ $year^{-1}$), 1990-2014**

| Year | Dairy cows | | | Growing Cattle | | | Other Mature Cattle | | |
|---|---|---|---|---|---|---|---|---|---|
| | Weight | GE | EF | Weight | GE | EF | Weight | GE | EF |
| **1990** | 550.0 | 241.6 | 103.0 | 272.0 | 80.4 | 29.8 | 581.3 | 152.9 | 65.2 |
| **1991** | 550.0 | 236.1 | 100.6 | 270.9 | 79.7 | 29.5 | 581.2 | 152.9 | 65.2 |
| **1992** | 550.0 | 225.2 | 96.0 | 267.5 | 77.6 | 28.7 | 581.3 | 152.9 | 65.2 |
| **1993** | 550.0 | 224.6 | 95.8 | 267.3 | 77.0 | 28.6 | 580.8 | 152.9 | 65.2 |
| **1994** | 550.0 | 230.9 | 98.4 | 268.5 | 77.9 | 28.9 | 581.6 | 153.0 | 65.2 |
| **1995** | 550.0 | 236.3 | 100.8 | 271.7 | 78.6 | 29.3 | 580.4 | 152.9 | 65.2 |
| **1996** | 550.0 | 242.3 | 103.3 | 269.6 | 77.9 | 29.0 | 581.0 | 152.9 | 65.2 |
| **1997** | 550.0 | 253.9 | 108.3 | 267.9 | 77.5 | 28.8 | 572.8 | 153.9 | 65.6 |
| **1998** | 550.0 | 258.0 | 110.0 | 270.5 | 77.7 | 29.0 | 555.2 | 150.1 | 64.0 |
| **1999** | 550.0 | 257.7 | 109.9 | 268.5 | 76.8 | 28.6 | 552.2 | 149.7 | 63.8 |
| **2000** | 555.0 | 264.2 | 112.6 | 262.5 | 76.0 | 28.1 | 541.6 | 147.6 | 62.9 |
| **2001** | 555.0 | 268.9 | 114.6 | 254.0 | 74.8 | 27.3 | 566.1 | 152.9 | 65.2 |
| **2002** | 555.0 | 265.9 | 113.3 | 264.2 | 76.1 | 28.2 | 556.9 | 154.4 | 65.8 |
| **2003** | 555.0 | 285.0 | 121.5 | 270.5 | 77.2 | 28.9 | 559.3 | 155.9 | 66.5 |
| **2004** | 555.0 | 276.3 | 117.8 | 261.3 | 75.6 | 27.9 | 563.3 | 158.7 | 67.7 |
| **2005** | 555.0 | 281.1 | 119.8 | 261.2 | 76.1 | 28.0 | 563.3 | 167.3 | 71.3 |
| **2006** | 560.0 | 286.2 | 122.0 | 267.7 | 76.4 | 28.5 | 564.3 | 168.8 | 72.0 |
| **2007** | 560.0 | 291.5 | 124.3 | 271.2 | 77.1 | 28.8 | 556.6 | 174.8 | 74.5 |
| **2008** | 560.0 | 296.9 | 126.6 | 268.9 | 76.5 | 28.5 | 560.6 | 165.2 | 70.4 |
| **2009** | 560.0 | 299.4 | 127.7 | 270.6 | 77.1 | 28.8 | 567.4 | 170.5 | 72.7 |
| **2010** | 560.0 | 302.3 | 128.9 | 272.5 | 77.5 | 29.0 | 569.6 | 173.8 | 74.1 |
| **2011** | 565.0 | 303.9 | 129.6 | 272.3 | 77.2 | 28.9 | 568.6 | 176.2 | 75.1 |
| **2012** | 565.0 | 308.3 | 131.5 | 273.6 | 77.9 | 29.2 | 572.3 | 179.4 | 76.5 |
| **2013** | 565.0 | 314.5 | 134.1 | 278.3 | 79.1 | 29.8 | 575.1 | 180.1 | 76.8 |
| **2014** | 565.0 | 318.7 | 135.9 | 274.1 | 78.7 | 29.4 | 575.0 | 182.4 | 77.8 |

Results of gross energy intake and emission factors calculation for non-dairy cattle from enteric fermentation are summarized in Table 5.12.

**Table 5.12 Gross energy (GE) intake (MJ $day^{-1}$) and methane emission factors (EF) from Enteric Fermentation for Non-dairy Cattle sub-groups (kg $CH_4$ $head^{-1}$ $year^{-1}$), 2014**

| Non-dairy Cattle sub-groups | | GE | EF |
|---|---|---|---|
| Young cattle under 1 year | dairy cattle calves | 58.2 | 18.6 |
| | beef cattle calves | 74.8 | 23.9 |
| Young cattle aged from 1 to 2 years | dairy cattle | 96.0 | 40.9 |
| | beef cattle | 123.2 | 52.5 |
| Mature non-dairy cattle over 2 years | bulls | 215.3 | 91.8 |
| | heifers | 127.1 | 54.2 |
| | other cows | 217.4 | 92.7 |
| IPCC default | | | 57 |

### 5.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6. The uncertainty associated with livestock population varies widely depending on the source, but according to 2006 IPCC Guidelines should be known within +20%. However, according to received information from CSB of Latvia, uncertainty of activity data describing numbers of livestock could be 2-3%. Generally, the uncertainty of activity data provided by CSB of Latvia is set as 2%. 2006 IPCC Guidelines declare that emission factors estimated using the Tier 1 method are unlikely to be known more accurately than +30% and may be uncertain to +50%. Tier 2 method is likely to be in the order of +20%[127].

According to the assumptions above, emission factors estimated using the Tier 1 method is set to be uncertain of 40%, but uncertainty of emission factors estimated by the Tier 2 is set as 20%.

### 5.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the agriculture sector in order to achieve these quality objectives. Quality control meetings are held annually between experts.

**Activity data check.** Livestock data were checked by an inventory compiler and CSB specialist. Livestock age sub-groups data that were collected by extrapolating methods are compared with statistical data of CSB to achieve correct total numbers. Data collection methods are documented in agriculture sector inventory compilers data base for GHG inventory purposes.

**Review of emission factors.** Country-specific emission factors derived with Tier 2 method are cross-checked against the IPCC defaults. Results of comparison of emission factors for methane emission from enteric fermentation of dairy cows and non-dairy cattle are shown below (Table 5.13):

**Table 5.13 Review of emission factors for enteric fermentation methane emissions**

| Category | Source | EF (kg $CH_4$ head$^{-1}$year$^{-1}$) |
|---|---|---|
| Dairy cows | Latvia, Tier 2, 2014 | 135.9 |
| | 2006 IPCC Guidelines (Western Europe)[128] | 117.0 |
| Non-dairy cattle | Latvia, Tier 2, 2014 (average) | 53.5 |
| | 2006 IPCC Guidelines (Western Europe)[58] | 57.0 |

Latvia uses higher emission factor for dairy cows based on a different feeding situation that is not totally characterized as stall fed (set for Tier 1). Also digestibility used for calculations of emission coefficient is lower (65% against 70% for Tier 1). In average enteric fermentation

[127] *2006 IPCC Guidelines. Volume 4, Chapter 10, page 10.33*
[128] *2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.11, page 10.29*

methane emission factor for non-dairy cattle is slightly lower than IPCC default, caused mainly by different feeding situation in Latvia.

### 5.2.5 Category-specific recalculations

For 2016 submission the main recalculations of methane emissions for the period 1900-2014 are done based on the implementation of new reporting categories for non-dairy cattle; implementation of new methodology to determine manure management and feeding situation distribution for all livestock; updating information of cattle weights based on latest expert judgements and adjusting amount of milk production per day to lactation period. Also new livestock category as *deer* is included in the inventory.

### 5.2.6 Category-specific planned improvements

Updating of digestible energy as percent of gross energy for cattle, according to feeding situation research is planned for the next inventory.

## *5.3 MANURE MANAGEMENT (CRF 3.B)*

### 5.3.1 Category description

The emission sources cover management of manure from domestic livestock. Latvia reports methane ($CH_4$) and nitrous oxide ($N_2O$) emissions from cattle (including groups represented in the chapter 1.2), sheep, swine (including mature swine as breeding sows and boars, piglets under 50 kg of weight, young breeding sows and fattening pigs), horses, goats and poultry (including layers, broilers, turkeys, ducks, geese and other poultry), as well as rabbits, fur-bearing animals and deer (Table 5.14).

When organic matter in livestock manure decomposes in anaerobic environment, methanogenic bacteria produce methane. The amount of methane produced from manure depends on livestock type and diet, special feeding and digestibility of food, as well as waste management system. The nitrous oxide estimated in this section is the nitrous oxide produced during the storage and treatment of manure before it is applied to land. Production of nitrous oxide during storage and treatment of animal waste occurs via combined nitrification-denitrification of nitrogen in animal waste.

**Table 5.14 Reported emissions under the subcategory manure management**

| CRF | Source | Emissions reported | Level |
|---|---|---|---|
| 3.B 1 | Dairy Cattle / Non-dairy Cattle (other mature and growing cattle) | $CH_4$, $N_2O$ | Tier 2, Tier 2 |
| 3.B 2 | Sheep | $CH_4$, $N_2O$ | Tier 1, Tier 2 |
| 3.B 3 | Swine | $CH_4$, $N_2O$ | Tier 2, Tier 2 |
| 3.B 4 | Other – Buffalo | NO | NA |
| 3.B 4 | Other – Camels | NO | NA |
| 3.B 4 | Other – Deer | $CH_4$, $N_2O$ | Tier 1, Tier 2 |
| 3.B 4 | Other – Goats | $CH_4$, $N_2O$ | Tier 1, Tier 2 |
| 3.B 4 | Other – Horses | $CH_4$, $N_2O$ | Tier 1, Tier 2 |
| 3.B 4 | Other – Mules and asses | NO | NA |
| 3.B 4 | Other – Poultry | $CH_4$, $N_2O$ | Tier 1, Tier 2 |
| 3.B 4 | Other – Rabbits | $N_2O$ | Tier 1, Tier 1 |
| 3.B 4 | Other – Fur-bearing animals | $N_2O$ | Tier 1, Tier 1 |

Methane emissions from manure management have decreased by 47.5% over the time period of 1990-2014 (Table 5.15). In 2014, methane emissions from manure management of domestic livestock increased by 0.21 kt or 5.5% compared with 2013. In 2014, total nitrous oxide emissions (including direct and indirect emissions) reached 0.35 kt. Direct nitrous oxide emissions decreased by 66.5% over the time period of 1990-2014 (Table 5.16).

**Table 5.15 Methane emissions from manure management by livestock category, 1990-2014 (kt)**

| Year | Dairy cattle | Non-dairy cattle | Sheep | Swine | Goats | Horses | Poultry | Rabbits | Fur-bearing animals | Deer | Total $CH_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1990** | 3.42 | 1.02 | 0.03 | 2.62 | 0.001 | 0.05 | 0.26 | 0.016 | 0.18 | ND | 7.58 |
| **1991** | 3.38 | 0.97 | 0.03 | 2.36 | 0.001 | 0.05 | 0.26 | 0.018 | 0.18 | ND | 7.24 |
| **1992** | 2.98 | 0.77 | 0.03 | 1.73 | 0.001 | 0.04 | 0.14 | 0.016 | 0.18 | ND | 5.88 |
| **1993** | 2.20 | 0.38 | 0.02 | 1.07 | 0.001 | 0.04 | 0.11 | 0.013 | 0.18 | ND | 4.01 |
| **1994** | 2.04 | 0.28 | 0.02 | 1.04 | 0.001 | 0.04 | 0.09 | 0.012 | 0.15 | ND | 3.68 |
| **1995** | 2.00 | 0.28 | 0.01 | 1.23 | 0.001 | 0.04 | 0.10 | 0.012 | 0.15 | ND | 3.82 |
| **1996** | 1.98 | 0.27 | 0.01 | 0.91 | 0.001 | 0.04 | 0.10 | 0.011 | 0.14 | ND | 3.47 |
| **1997** | 2.05 | 0.25 | 0.01 | 0.92 | 0.001 | 0.04 | 0.09 | 0.007 | 0.06 | ND | 3.42 |
| **1998** | 1.97 | 0.22 | 0.01 | 0.91 | 0.001 | 0.03 | 0.08 | 0.008 | 0.04 | ND | 3.28 |
| **1999** | 1.73 | 0.20 | 0.01 | 0.94 | 0.001 | 0.03 | 0.09 | 0.006 | 0.06 | ND | 3.05 |
| **2000** | 1.82 | 0.19 | 0.01 | 0.93 | 0.001 | 0.03 | 0.08 | 0.009 | 0.07 | ND | 3.13 |
| **2001** | 2.13 | 0.20 | 0.01 | 1.07 | 0.001 | 0.03 | 0.09 | 0.012 | 0.08 | ND | 3.62 |
| **2002** | 2.10 | 0.21 | 0.01 | 1.19 | 0.002 | 0.03 | 0.10 | 0.011 | 0.08 | ND | 3.72 |
| **2003** | 2.08 | 0.23 | 0.01 | 1.22 | 0.002 | 0.02 | 0.10 | 0.012 | 0.08 | ND | 3.75 |
| **2004** | 2.06 | 0.22 | 0.01 | 1.17 | 0.002 | 0.02 | 0.10 | 0.011 | 0.10 | ND | 3.69 |
| **2005** | 2.11 | 0.23 | 0.01 | 1.21 | 0.002 | 0.02 | 0.10 | 0.008 | 0.10 | ND | 3.80 |
| **2006** | 2.18 | 0.24 | 0.01 | 1.22 | 0.002 | 0.02 | 0.11 | 0.007 | 0.12 | 0.001 | 3.92 |
| **2007** | 2.31 | 0.27 | 0.01 | 1.27 | 0.002 | 0.02 | 0.12 | 0.008 | 0.12 | 0.001 | 4.14 |
| **2008** | 2.34 | 0.26 | 0.01 | 1.20 | 0.002 | 0.02 | 0.11 | 0.005 | 0.13 | 0.002 | 4.09 |
| **2009** | 2.39 | 0.27 | 0.01 | 1.18 | 0.002 | 0.02 | 0.12 | 0.004 | 0.11 | 0.002 | 4.10 |
| **2010** | 2.31 | 0.28 | 0.01 | 1.15 | 0.002 | 0.02 | 0.12 | 0.003 | 0.11 | 0.002 | 4.01 |
| **2011** | 2.39 | 0.28 | 0.02 | 1.09 | 0.002 | 0.02 | 0.10 | 0.003 | 0.12 | 0.003 | 4.03 |
| **2012** | 2.28 | 0.30 | 0.02 | 0.91 | 0.002 | 0.02 | 0.10 | 0.003 | 0.16 | 0.003 | 3.79 |
| **2013** | 2.28 | 0.32 | 0.02 | 0.88 | 0.002 | 0.02 | 0.10 | 0.003 | 0.16 | 0.003 | 3.77 |
| **2014** | 2.49 | 0.34 | 0.02 | 0.83 | 0.002 | 0.02 | 0.08 | 0.003 | 0.21 | 0.004 | 3.98 |
| **Share of total % in 2014** | 62.4% | 8.5% | 0.4% | 20.7% | 0.0% | 0.4% | 1.9% | 0.1% | 5.4% | 0.1% | 100.0% |
| **2014 versus 2013** | +9.2% | +6.1% | +9.1% | -6.3% | -2.4% | -5.6% | -23.6% | -1.5% | +35.5% | +14.2% | +5.5% |
| **2014 versus 1990** | -27.3% | -66.9% | -43.8% | -68.4% | +127.8% | -67.3% | -70.6% | -80.2% | +20.6% | ND | -47.5% |

In 2014, direct emissions from manure management increased by 0.01 kt or 2.4% compared to 2013. The fluctuation of emissions is related to the variation of animal numbers, as well as changes in the distribution of livestock MMS. Similarly indirect nitrous oxide emissions decreased by 69.5% over the time period of 1990-2014, showing the tendency to increase by 2.2% in the last inventory year compared to 2013 (Table 5.16).

**Table 5.16 Nitrous oxide emissions from manure management by livestock category, 1990-2014* (kt)**

| Year | Dairy cattle | Non-dairy cattle | Sheep | Swine | Goats | Horses | Poultry | Rabbits | Fur-bearing animals | Deer | Total direct, $N_2O$ | Total indirect, $N_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1990** | 0.32 | 0.09 | 0.006 | 0.137 | 0.000 | 0.010 | 0.038 | 0.012 | 0.017 | ND | 0.62 | 0.46 |
| **1991** | 0.31 | 0.08 | 0.007 | 0.120 | 0.000 | 0.010 | 0.039 | 0.014 | 0.017 | ND | 0.60 | 0.44 |
| **1992** | 0.28 | 0.07 | 0.006 | 0.087 | 0.000 | 0.009 | 0.021 | 0.013 | 0.017 | ND | 0.50 | 0.35 |
| **1993** | 0.20 | 0.04 | 0.004 | 0.053 | 0.000 | 0.008 | 0.016 | 0.010 | 0.017 | ND | 0.35 | 0.23 |
| **1994** | 0.18 | 0.03 | 0.003 | 0.049 | 0.000 | 0.009 | 0.014 | 0.010 | 0.014 | ND | 0.31 | 0.21 |
| **1995** | 0.17 | 0.03 | 0.003 | 0.058 | 0.000 | 0.009 | 0.016 | 0.010 | 0.014 | ND | 0.31 | 0.21 |
| **1996** | 0.18 | 0.03 | 0.002 | 0.040 | 0.000 | 0.008 | 0.015 | 0.009 | 0.013 | ND | 0.29 | 0.19 |
| **1997** | 0.18 | 0.02 | 0.002 | 0.040 | 0.000 | 0.007 | 0.014 | 0.006 | 0.006 | ND | 0.28 | 0.18 |
| **1998** | 0.17 | 0.02 | 0.001 | 0.038 | 0.000 | 0.007 | 0.013 | 0.006 | 0.004 | ND | 0.26 | 0.17 |
| **1999** | 0.14 | 0.02 | 0.001 | 0.037 | 0.000 | 0.006 | 0.013 | 0.005 | 0.006 | ND | 0.23 | 0.15 |
| **2000** | 0.14 | 0.02 | 0.001 | 0.036 | 0.000 | 0.006 | 0.013 | 0.007 | 0.006 | ND | 0.23 | 0.15 |
| **2001** | 0.15 | 0.02 | 0.001 | 0.039 | 0.000 | 0.006 | 0.015 | 0.010 | 0.008 | ND | 0.25 | 0.16 |
| **2002** | 0.14 | 0.02 | 0.001 | 0.041 | 0.001 | 0.006 | 0.016 | 0.009 | 0.008 | ND | 0.25 | 0.16 |
| **2003** | 0.14 | 0.02 | 0.001 | 0.040 | 0.001 | 0.005 | 0.015 | 0.009 | 0.008 | ND | 0.24 | 0.16 |
| **2004** | 0.14 | 0.02 | 0.001 | 0.037 | 0.001 | 0.005 | 0.016 | 0.009 | 0.009 | ND | 0.23 | 0.16 |
| **2005** | 0.14 | 0.02 | 0.003 | 0.037 | 0.001 | 0.005 | 0.016 | 0.006 | 0.009 | ND | 0.24 | 0.15 |
| **2006** | 0.14 | 0.02 | 0.003 | 0.036 | 0.001 | 0.004 | 0.017 | 0.006 | 0.012 | 0.000 | 0.24 | 0.15 |
| **2007** | 0.14 | 0.03 | 0.004 | 0.037 | 0.001 | 0.004 | 0.018 | 0.006 | 0.012 | 0.000 | 0.24 | 0.15 |
| **2008** | 0.13 | 0.02 | 0.005 | 0.034 | 0.001 | 0.004 | 0.017 | 0.004 | 0.013 | 0.000 | 0.23 | 0.15 |
| **2009** | 0.13 | 0.02 | 0.006 | 0.032 | 0.001 | 0.004 | 0.018 | 0.003 | 0.011 | 0.000 | 0.23 | 0.14 |
| **2010** | 0.12 | 0.02 | 0.006 | 0.031 | 0.001 | 0.004 | 0.018 | 0.002 | 0.011 | 0.000 | 0.22 | 0.14 |
| **2011** | 0.12 | 0.02 | 0.006 | 0.028 | 0.001 | 0.004 | 0.015 | 0.003 | 0.012 | 0.000 | 0.22 | 0.14 |
| **2012** | 0.12 | 0.02 | 0.007 | 0.023 | 0.001 | 0.004 | 0.015 | 0.002 | 0.015 | 0.000 | 0.21 | 0.14 |
| **2013** | 0.11 | 0.02 | 0.007 | 0.021 | 0.001 | 0.004 | 0.015 | 0.002 | 0.015 | 0.000 | 0.20 | 0.14 |
| **2014** | 0.12 | 0.03 | 0.007 | 0.019 | 0.001 | 0.003 | 0.011 | 0.002 | 0.021 | 0.000 | 0.21 | 0.14 |
| **Share of total % in 2014** | 56.6% | 12.3% | 3.6% | 9.1% | 0.5% | 1.6% | 5.4% | 1.2% | 9.8% | 0.0% | 100.0% | |
| **2014 versus 2013** | +3.3% | +4.8% | +9.1% | -10.4% | -2.4% | -5.6% | -24.0% | -1.5% | +35.5% | 0.0% | +2.4% | +2.2% |
| **2014 versus 1990** | -62.9% | -70.1% | +21.8% | -86.1% | +393.5% | -66.6% | -70.1% | -80.2% | +20.6% | ND | -66.5% | -69.5% |

**emissions from pasture not included, they are reported under 3.D Managed soils*

### 5.3.2 Methodological issues

The 2006 IPCC Guidelines include two tiers to estimate emissions from livestock manure. The Tier 1 approach requires livestock population data by animal species/category and climate region in order to estimate emissions. The Tier 2 approach requires detailed information on animal characteristics and the manner in which manure is managed; it is encouraged to be used for countries where a particular livestock species/category represents a significant share of emissions. The process of developing Tier 2 emission factors involves determining the mass of volatile solids excreted by the animals (VS, in kg) along with the maximum methane producing capacity for the manure (Bo, in $m^3$ kg of VS). In addition, a methane conversion factor (MCF) that accounts for the influence of climate on methane production must be obtained for each manure management system.

Methane emissions from manure management for sheep, goats, horses, poultry (divided as layers broilers, turkeys, ducks, geese and others), rabbits, fur-bearing animals and deer were calculated by using Tier 1 methodology by multiplying the number of the animals with the default emission factor for each animal category according to the 2006 IPCC Guidelines[129]:

$$CH_4\ manure = \sum_{(T)} \frac{\left(EF_{(T)} \cdot N_{(T)}\right)}{10^6}$$

*where:*
*$CH_{4\ Manure}$ = $CH_4$ emissions from manure management, for a defined population, kt $CH_4$ $yr^{-1}$*
*$EF_{(T)}$ = emission factor for the defined livestock population, kg $CH_4$ $head^{-1}$ $yr^{-1}$*
*$N_{(T)}$ = the number of head of livestock species / category T in the country*
*T = species/category of livestock*

Emission factors for Tier 1 methodology calculations were chosen as for *cool* climate region and are represented in Table 5.17. The original source of default emission factors is 2006 IPCC Guidelines[130]. Emission factor for deer is derived based on studies of Karlengen (2012)[131].

**Table 5.17 Methane emission factors from manure management**

| Animal category | Emission factor (kg $head^{-1}$ $year^{-1}$) |
|---|---|
| Sheep | 0.19 |
| Goats | 0.13 |
| Horses | 1.56 |
| Layers | 0.03 |
| Broilers and others | 0.02 |
| Turkeys | 0.09 |
| Ducks | 0.02 |
| Geese | 0.02 |
| Rabbits | 0.08 |
| Fur-bearing animals | 0.68 |
| Deer | 0.29 |

For dairy cattle, non-dairy cattle and swine the Tier 2 approach was used for estimating methane emissions from manure management systems as dairy cattle and swine represent a significant share of total emissions from agriculture sector. This method requires detailed information on animal characteristics and the manner in which manure is managed.

*[129] 2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.22, page 10.37*
*[130] 2006 IPCC Guidelines. Volume 4, Chapter 10, Tables 10.15 and 10.16, page 10.40-10.41*
*[131] Karlengen, I. J., Svihus, B., Kjos, N. P. & Harstad, O. M. (2012): Husdyrgjødsel; oppdatering avmengder gjødsel og utskillelse av nitrogen, fosfor og kalium. Sluttrapport. (Manure; anupdate of amounts of manure and excretion of nitrogen, phosphorus and potassium. Final report). Ås: Departement of Animal and Aquacultural Sciences, Norwegian University of LifeSciences (Institutt for husdyr- og akvakulturvitenskap, NMBU-Norges miljø- ogbiovitenskapelige universitet)*

Methane emission factors for cattle and swine were derived from the 2006 IPCC Guidelines[132]:

$$EF_T = (VS_T \cdot 365) \cdot \left[B_{O(T)} \cdot 0.67 \frac{kg}{m^3} \cdot \sum_{S,k} \frac{MCF_{S,k}}{100} \cdot MS_{T,S,k}\right]$$

where:

*$EF_{(T)}$ = annual $CH_4$ emission factor for livestock category T, kg $CH_4$ animal$^{-1}$ yr$^{-1}$*
*$VS_{(T)}$ = daily volatile solid excreted for livestock category T, kg dry matter animal$^{-1}$ day$^{-1}$*
*$Bo_{(T)}$ = maximum methane producing capacity for manure produced by livestock category T, m$^3$ $CH_4$ kg$^{-1}$of VS excreted*
*$MCF_{(S,k)}$ = methane conversion factors for each manure management system by climate region k, % (Solid Storage – 2%, Liquid Storage (with crust) – 10%, Pasture/Range/Paddock – 1%;Anaerobic Digester – 2% as represented in table 10.17, page 10.44, 2006 IPCC)*
*$MS_{(T,S,k)}$ = fraction of livestock category manure handled using manure management system in climate region k, dimensionless*
*0.67 = conversion factor of m$^3$ $CH_4$ to kilograms $CH_4$*
*365 = basis for calculating annual VS production, days yr$^{-1}$*

Default methane conversion factor[133] MCF values for manure management systems: solid storage – 2%, liquid storage (with crust) – 10%, pasture/range/paddock – 1%; as well as methane producing capacities[134] $B_0$ (0.24 for dairy cows, 0.17 for other cattle and 0.45 for swine) are used in Latvia's National Greenhouse Gas Inventory 2016. In response to question raised by Technical expert review team (TERT) during European Union Effort sharing decision (EU ESD) voluntary review in 2015, the estimation of methane emissions from anaerobic digesters now consider MCF value 2%. For anaerobic digester 2006 IPCC Guidelines recommends MCF in the range from 0 to 100%. Based on available information and expert judgement from Latvian Biogas Association, it is assumed that anaerobic digestation completely is referred to energy production and storage of manure for a given period before transfer to the digester is not typical for Latvia. While national study will proceed, that is required from TERT, methane leakage around 2% from biogas production will be implemented in the national inventory based on Swedish experience[135].

In 2014, significant part of laying hens manure is used for biogas production. According to information provided above, methane emissions form laying hens estimated by Tier 1 are corrected by fallowing assumption:

$$CH_{4\ layer\ manure} = N_{(L)} \bullet EF_{(L)} \bullet (1 - MMS(anaerobic\ digester)) + N_{(L)} \bullet EF_{(L)} \bullet MMS(anaerobic\ digester) \bullet 2\%$$

*where:*
*$CH_4$ layer manure = $CH_4$ emissions from manure management, for laying hens, kt $CH_4$ yr$^{-1}$*
*$N_{(L)}$ = the number of laying hens*
*$EF_{(L)}$ = emission factor for the laying hens population, kg $CH_4$ head$^{-1}$ yr$^{-1}$, Table 5.17*
*MMS (anaerobic digester) = share of manure digested*

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[132] *2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.23, page 10.41*
[133] *2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.17, page 10.44*
[134] *2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10A-4, 10A-5, 10A-7, page 10.77-10.80*
[135] *Jonerholm K., Lundborg H. (2012) Methane losses in the biogas system. Available at http://www.balticbiogasbus.eu/web/Upload/Supply_of_biogas/Act_4_6/Annex/Methane%20losses.pdf*

Daily volatile solid (VS) excretion rate (per day on a dry-matter weight basis) was estimated as represented in the 2006 IPCC Guidelines[136]:

$$VS = \left[GE \cdot \left(1 - \frac{DE\%}{100}\right) + (UE \cdot GE)\right] \cdot \left[\left(\frac{1 - ASH}{18.45}\right)\right]$$

*where:*
*VS = volatile solid excretion per day on a dry-organic matter basis, kg VS day$^{-1}$*
*GE = gross energy intake, MJ day$^{-1}$*
*DE% = digestibility of the feed in percent (65% for cattle, 80% for breeding swine and fattening pigs, 85% for piglets under 50 kg)*
*(UE • GE) = urinary energy expressed as fraction of GE (0.04•GE are considered as urinary energy)*
*ASH = the ash content of manure calculated as a fraction of the dry matter feed intake (0.08 for cattle and 0.02 for swine)*
*18.45 = conversion factor for dietary GE per kg of dry matter (MJ kg$^{-1}$)*

Results of calculation of the country specific methane emissions factors from manure management are included in Table 5.18.

**Table 5.18 Daily volatile solid (VS) values and methane emission factors (EF) of manure management for cattle, 1990-2014**

| Year | Dairy cows | | Growing Cattle | | Other Mature Cattle | |
|---|---|---|---|---|---|---|
| | VS (kg day$^{-1}$) | EF (kg $CH_4$ head$^{-1}$ year$^{-1}$) | VS (kg day$^{-1}$) | EF (kg $CH_4$ head$^{-1}$ year$^{-1}$) | VS (kg day$^{-1}$) | EF (kg $CH_4$ head$^{-1}$ year$^{-1}$) |
| **1990** | 4.70 | 6.39 | 1.56 | 1.09 | 2.97 | 1.59 |
| **1991** | 4.59 | 6.35 | 1.55 | 1.09 | 2.97 | 1.59 |
| **1992** | 4.38 | 6.19 | 1.51 | 1.12 | 2.97 | 1.59 |
| **1993** | 4.37 | 6.27 | 1.50 | 1.12 | 2.97 | 1.59 |
| **1994** | 4.49 | 6.55 | 1.52 | 1.11 | 2.98 | 1.59 |
| **1995** | 4.60 | 6.84 | 1.53 | 1.12 | 2.97 | 1.59 |
| **1996** | 4.71 | 7.21 | 1.51 | 1.12 | 2.97 | 1.59 |
| **1997** | 4.94 | 7.80 | 1.51 | 1.12 | 2.99 | 1.60 |
| **1998** | 5.02 | 8.14 | 1.51 | 1.13 | 2.92 | 1.56 |
| **1999** | 5.01 | 8.39 | 1.49 | 1.13 | 2.91 | 1.55 |
| **2000** | 5.14 | 8.90 | 1.48 | 1.11 | 2.87 | 1.53 |
| **2001** | 5.23 | 10.18 | 1.46 | 1.09 | 2.97 | 1.59 |
| **2002** | 5.17 | 10.26 | 1.48 | 1.12 | 3.00 | 1.60 |
| **2003** | 5.54 | 11.18 | 1.50 | 1.14 | 3.03 | 1.62 |
| **2004** | 5.37 | 11.04 | 1.47 | 1.11 | 3.09 | 1.65 |
| **2005** | 5.47 | 11.42 | 1.48 | 1.10 | 3.25 | 1.74 |
| **2006** | 5.57 | 11.95 | 1.49 | 1.14 | 3.28 | 1.75 |
| **2007** | 5.67 | 12.82 | 1.50 | 1.15 | 3.40 | 1.82 |
| **2008** | 5.77 | 13.72 | 1.49 | 1.15 | 3.21 | 1.72 |
| **2009** | 5.82 | 14.44 | 1.50 | 1.15 | 3.31 | 1.77 |
| **2010** | 5.88 | 14.09 | 1.51 | 1.15 | 3.38 | 1.80 |
| **2011** | 5.91 | 14.54 | 1.50 | 1.15 | 3.43 | 1.83 |
| **2012** | 6.00 | 13.86 | 1.52 | 1.15 | 3.49 | 1.86 |
| **2013** | 6.12 | 13.80 | 1.54 | 1.15 | 3.50 | 1.87 |
| **2014** | 6.20 | 14.98 | 1.53 | 1.13 | 3.55 | 1.89 |

*[136] 2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 20.24, page 10.42*

Country specific methane emissions factors for non-dairy cattle groups are lower than IPCC default emission factor, because the amount of manure stored in liquid/ slurry based systems for non-dairy cattle in Latvia is assumed to be zero, that is lower than IPCC default share (Table 5.18, Table 5.19).

**Table 5.19 Daily volatile solid (VS) values and methane emission factors (EF) of manure management for non-dairy cattle sub-groups, 2014**

| Non-dairy cattle sub-groups | | VS (kg day$^{-1}$) | EF (kg $CH_4$ head$^{-1}$ year$^{-1}$) |
|---|---|---|---|
| Young cattle under 1 year | dairy cattle calves | 1.13 | 0.96 |
| | beef cattle calves | 1.46 | 0.78 |
| Young cattle aged from 1 to 2 years | dairy cattle | 1.87 | 1.58 |
| | beef cattle | 2.40 | 1.28 |
| Mature non-dairy cattle over 2 years | bulls | 4.19 | 2.24 |
| | heifers | 2.47 | 1.32 |
| | other cows | 4.23 | 2.26 |
| IPCC default[137] | | | 6 |

As Tier 2 methodology to estimate methane emissions from manure management requires information of gross energy intake by swine, but enteric fermentation emission for swine was derived by Tier 1 methodology, the Estonian inventory[138] approach to calculate gross energy intake based on swine live weight and digestible energy was adopted:

$$GE = \frac{ME}{DE\%}$$

*where:*
*GE = gross energy intake, MJ day$^{-1}$*
*DE% = digestible energy as percentage of gross energy, %*
*ME =2.0 x W = energy intake for maintenance and growth MJ day$^{-1}$*
*W = live weight of swine, kg*

Feed digestibility data for swine are taken from 2006 IPCC Guidelines: 80% for breeding sows, boars, young breeding sows and fattening pigs (IPCC suggested range 70-80% for confinement mature swine) and 85% for piglets (IPCC suggested range 80-90% for confinement growing swine[139]).

Results of the calculation of methane emission from manure management for swine are presented in Table 5.20.

**Table 5.20 Estimation parameters and emission factors (EF) of methane emission from manure management for swine, 1990-2014**

| Year | Weight (head$^{-1}$ year$^{-1}$) | GE (MJ day$^{-1}$) | VS (kg day$^{-1}$) | EF(kg $CH_4$ head$^{-1}$ year$^{-1}$) |
|---|---|---|---|---|
| **1990** | 74.6 | 35.4 | 0.40 | 1.87 |
| **1991** | 73.6 | 35.1 | 0.39 | 1.89 |
| **1992** | 76.8 | 36.0 | 0.40 | 2.00 |
| **1993** | 85.7 | 38.6 | 0.44 | 2.22 |
| **1994** | 75.1 | 35.5 | 0.40 | 2.08 |
| **1995** | 80.2 | 36.8 | 0.41 | 2.23 |

[137] *2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.14, page 10.38*
[138] *Estonian NIR (2015). Available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8812.php*
[139] *2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.2, page 10.14*

| Year | Weight ($head^{-1}$ $year^{-1}$) | GE (MJ $day^{-1}$) | VS (kg $day^{-1}$) | EF(kg $CH_4$ $head^{-1}$ $year^{-1}$) |
|---|---|---|---|---|
| **1996** | 66.6 | 32.5 | 0.35 | 1.99 |
| **1997** | 70.6 | 33.5 | 0.37 | 2.13 |
| **1998** | 68.9 | 32.9 | 0.36 | 2.16 |
| **1999** | 70.1 | 33.7 | 0.37 | 2.32 |
| **2000** | 69.0 | 33.5 | 0.37 | 2.37 |
| **2001** | 68.6 | 33.2 | 0.37 | 2.49 |
| **2002** | 67.9 | 33.1 | 0.37 | 2.61 |
| **2003** | 67.9 | 33.1 | 0.36 | 2.74 |
| **2004** | 64.3 | 31.7 | 0.34 | 2.69 |
| **2005** | 65.0 | 31.9 | 0.35 | 2.83 |
| **2006** | 65.8 | 32.2 | 0.35 | 2.94 |
| **2007** | 66.9 | 32.5 | 0.36 | 3.06 |
| **2008** | 66.3 | 32.4 | 0.35 | 3.13 |
| **2009** | 65.0 | 31.8 | 0.35 | 3.13 |
| **2010** | 65.4 | 32.0 | 0.35 | 2.95 |
| **2011** | 64.5 | 31.6 | 0.34 | 2.91 |
| **2012** | 62.9 | 31.2 | 0.34 | 2.56 |
| **2013** | 62.5 | 31.1 | 0.34 | 2.40 |
| **2014** | 64.3 | 31.8 | 0.35 | 2.36 |

Table 5.21 shows main methane emission calculation results for all swine sub-groups and default manure management methane emission coefficients recommended by IPCC for Western Europe. Estimated emission coefficients are lower than IPCC default mainly explained by different distribution of manure management systems.

**Table 5.21 Typical animal weight, average gross energy (GE) intake, volatile solid (VS) values and emission factors (EF) for estimation of methane emission from manure management for swine sub-groups, 2014**

| Swine sub-groups | Number, (thousand heads) | Weight, ($head^{-1}$ $year^{-1}$) | GE, (MJ $day^{-1}$) | VS, (kg $day^{-1}$) | EF, (kg $CH_4$ $head^{-1}$ $year^{-1}$) |
|---|---|---|---|---|---|
| Piglets under 50 kg of weight (under 4 months) | 169.9 | 27.5 | 19.0 | 0.17 | 1.16 |
| Young breeding sows and fattening pigs | 151.7 | 75.0 | 38.0 | 0.44 | 3.02 |
| Mature breeding sows and boars | 27.7 | 232 | 77.3 | 0.90 | 6.14 |
| IPCC default[140] | | | | | 6-9 |

2006 IPCC Guidelines methodology was used for estimating nitrous oxide emission from manure management by multiplying the total amount of N excretion (from all animal species/categories) in each type of manure management system by an emission factor for that type of manure management system. Emissions are then summed over all manure management systems. Direct nitrous oxide emissions (kg $N_2O$ $yr^{-1}$) from manure management have been calculated by using 2006 IPCC Guidelines[141]:

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_T \left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)}\right)\right] \cdot EF_{3(S)}\right] \cdot \frac{44}{28}$$

*[140] 2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.14, page 10.38 (Western Europe)*
*[141] 2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 20.25, page 10.54*

*where:*
*$N_2O_{D(mm)}$ = direct $N_2O$ emissions from Manure Management in the country, kg $N_2O$ $yr^{-1}$*
*$N_{(T)}$ = number of head of livestock species/category T in the country*
*$Nex_{(T)}$ = annual average N excretion per head of species/category T in the country, kg N $animal^{-1}$ $yr^{-1}$*
*$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system in the country, dimensionless*
*$EF_{3(S)}$ = emission factor for direct $N_2O$ emissions from manure management system S in the country, kg $N_2O$-N $kg^{-1}$ N in manure management system*
*S = manure management system*
*T = species/category of livestock*

The amount of nitrogen excreted annually per animal has been divided among different manure management systems and multiplied with the IPCC default emission factor for each manure management system. The manure management systems (S) reported in the inventory are:

- liquid system;
- solid storage;
- pasture/range/paddock;
- anaerobic digester.

Following emission factors for direct nitrous oxide emissions from manure management were implemented: $EF_3$ = 0.005 for liquid manure/slurry with natural crust cover; $EF_3$ = 0.005 for solid storage; $EF_3$ = 0 for pasture/range/paddock; $EF_3$ = 0 for digester (2006 IPCC Guidelines[142]). Data about the distribution of MMS according to the national studies are available in Annex A.3.7 Agriculture. Nitrous oxide emissions from pasture are calculated under manure management, but are reported under category *Urine and dung deposited by grazing animals* in CRF 3.D.

Data of N excretion during the year per each livestock category used for the inventory are country specific and are obtained from national studies[143] or calculated fallowing by 2006 IPCC Guidelines. IPCC default annual average nitrogen excretion rate was used for rabbits and fur-bearing animals[144]. EMEP/EEA recommended N excretion values are used for poultry, except layers[145]. N excretion rate for deer is adopted from Norwegian inventory[146] as average value represented for deer and reindeer. All N excretion values used in the inventory are represented in Table 5.22.

**Table 5.22 Average N excretions per head of animal (N, kg $year^{-1}$)**

| Livestock category | 1990-2004 | 2005-2014 | Source |
|---|---|---|---|
| Sheep | 6 | 13 | National studies |
| Goats | 6 | 13 | National studies |
| Horses | 46 | 47 | National studies |
| Layers | 0.6 | 0.6 | National studies |
| Broilers and others | 0.36 | 0.36 | EMEP/EEA 2013 |
| Turkeys | 1.64 | 1.64 | EMEP/EEA 2013 |

*142 2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.21, page 10.62*
*143 Fertiliser Recommendations for Agricultural Crops (2013) Ed.A. Karklins and A.Ruza. Jelgava: LLU, 55 p.*
*144 2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.19, page 10.59*
*145 EMEP/EEA Air pollutant emission inventory guidebook (2013) 3.B Manure management. European Environment Agency. Table 3.7, page 27*
*146 Norwegian NIR (2015) Available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8812.php*

| Livestock category | 1990-2004 | 2005-2014 | Source |
|---|---|---|---|
| Ducks | 1.26 | 1.26 | EMEP/EEA 2013 |
| Geese | 0.55 | 0.55 | EMEP/EEA 2013 |
| Rabbit | 8.1 | 8.1 | IPCC default |
| Fur – bearing animals | 8.34 | 8.34 | IPCC default |
| Deer | 9 | 9 | Norwegian NIR |

Values about annual N excretion ($Nex_{(T)}$) per animal for dairy cattle and non-dairy cattle were calculated according to *IPCC* Tier 2 methodology[147]:

$$Nex_{(T)} = N_{intake} \cdot (1 - N_{retention})$$

*where:*

*$Nex_{(T)}$ = annual N excretion rates, kg N animal$^{-1}$ yr$^{-1}$*

*$N_{intake\,(T)}$ = the annual N intake per head of animal of species/category T, kg N animal$^{-1}$ yr$^{-1}$*

*$N_{retention\,(T)}$ = fraction of annual N intake that is retained by animal of species/category T, dimensionless*

The daily N intake per head of each cattle category is calculated as[148]:

$$N_{intake\,(T)} = \frac{GE}{18.45} \cdot \left( \frac{\frac{CP\%}{100}}{6.25} \right)$$

*where:*

*$N_{intake\,(T)}$ = daily N consumed per animal of category T, kg N animal$^{-1}$ day$^{-1}$*

*GE = gross energy intake of the animal, MJ animal$^{-1}$ day$^{1}$*

*18.45 = conversion factor for dietary GE per kg of dry matter, MJ kg$^{-1}$*

*CP% = percent crude protein in diet, input*

*6.25 = conversion from kg of dietary protein to kg of dietary N, kg feed protein (kg N$^{-1}$)*

The daily N retention per animal head of species/category is estimated as[149]:

$$N_{retention\,(T)} = \left[ \frac{Milk \cdot \frac{(Milk\ PR\%)}{100}}{6.38} \right] + \left[ \frac{WG \cdot \left[ 268 - \left( \frac{7.03\ NE_g}{WG} \right) \right]}{\frac{1000}{6.25}} \right]$$

*where:*

*$N_{retention(T)}$ = daily N retained per animal of category T, kg N animal$^{-1}$ day$^{-1}$*

*Milk = milk production, kg animal$^{-1}$ day$^{-1}$ (dairy cows only)*

*Milk PR% = percent of protein in milk, calculated as [1.9 + 0.4 · %Fat]*

*6.38 = conversion from milk protein to milk N, kg Protein (kg N)$^{-1}$*

*WG = weight gain, input for each livestock category, kg day$^{-1}$*

*268 and 7.03 = constants*

*Neg = net energy for growth, MJ day$^{-1}$*

*6.25 = conversion from kg dietary protein to kg dietary N, kgProtein (kg N)$^{-1}$*

Crude protein (CP) values are adopted from national studies regarding to feeding requirements for cattle[150] Based on milk yield and milk fat content data, CP=14% (1990-1995) and CP=15% is set for dairy cows. For other cattle CP values ranging from 9% to 14%.

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*[147] 2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.31, page 10.58*

*[148] 2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.32, page 10.58*

*[149] 2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.33, page 10.60*

*[150] Latvietis J. (1994) Govju ēdināšanas normas. Jelgava: LLU, p.102*

Annual N excretion rate for swine is derived by IPCC methodology[151] by using typical animal mass (TAM) data:

$$Nex_{(T)} = N_{rate} \cdot \frac{TAM}{1000} \cdot 365$$

*where:*

*$N_{ex\,(T)}$ = annual N excretion rates, kg N animal$^{-1}$ yr$^{-1}$*

*$N_{rate\,(T)}$ = default N excretion rate, kg N (1000 kg mass) $^{-1}$ day$^{-1}$(Market swine=0.52, Breeding swine=0.42[152])*

*TAM = typical anima mass, kg livestock$^{-1}$*

Calculated values of N excretion ($N_{ex(T)}$) per animal for dairy cattle, non-dairy cattle and swine for reporting in CRF are represented in Table 5.23.

**Table 5.23 N excretion rates for dairy, non-dairy cattle and swine, 1990-2014 (kg N animal$^{-1}$ yr$^{-1}$)**

| Year | Dairy Cattle | Growing Cattle | Other Mature Cattle | Swine |
|---|---|---|---|---|
| **1990** | 85.8 | 20.1 | 58.6 | 12.4 |
| **1991** | 84.6 | 20.1 | 58.6 | 12.3 |
| **1992** | 82.2 | 19.9 | 58.6 | 12.8 |
| **1993** | 82.1 | 19.7 | 58.6 | 14.1 |
| **1994** | 83.5 | 19.8 | 58.6 | 12.5 |
| **1995** | 84.7 | 20.0 | 58.5 | 13.3 |
| **1996** | 93.8 | 19.8 | 58.6 | 11.2 |
| **1997** | 96.8 | 19.7 | 58.1 | 11.7 |
| **1998** | 97.8 | 19.8 | 56.3 | 11.5 |
| **1999** | 97.7 | 19.6 | 56.0 | 11.7 |
| **2000** | 99.6 | 19.5 | 55.0 | 11.6 |
| **2001** | 100.8 | 19.2 | 57.4 | 11.5 |
| **2002** | 100.0 | 19.5 | 56.9 | 11.4 |
| **2003** | 105.2 | 19.7 | 57.3 | 11.4 |
| **2004** | 102.7 | 19.3 | 57.9 | 10.8 |
| **2005** | 104.0 | 19.4 | 58.9 | 10.9 |
| **2006** | 105.5 | 19.5 | 59.1 | 11.0 |
| **2007** | 106.9 | 19.8 | 59.2 | 11.2 |
| **2008** | 108.3 | 19.7 | 58.4 | 11.1 |
| **2009** | 108.9 | 19.7 | 59.6 | 10.9 |
| **2010** | 109.6 | 19.8 | 60.1 | 11.0 |
| **2011** | 110.2 | 19.7 | 60.3 | 10.8 |
| **2012** | 111.3 | 19.8 | 61.0 | 10.6 |
| **2013** | 112.8 | 20.0 | 61.3 | 10.5 |
| **2014** | 113.8 | 19.9 | 61.5 | 10.8 |

Detailed information on estimation results for swine subgroups is available in Table 5.24. Swine weight data are based on the judgement of Latvia University of Agriculture and Latvian pig breeding association experts.

*[151] 2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.30, page 10.57*

*[152] 2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.19, page 10.59*

**Table 5.24 Typical animal weight, average gross energy (GE) intake, volatile solid (VS) and emission factors (EF) for estimation of methane emission from manure management for swine sub-groups, including the number of swine, 2014**

| Swine sub-groups | Number (thousand heads) | Weight (kg head$^{-1}$) | GE (MJ day$^{-1}$) | VS (kg day$^{-1}$) | EF (kg $CH_4$ head$^{-1}$ year$^{-1}$) |
|---|---|---|---|---|---|
| Piglets under 50 kg of weight (under 4 months) | 169.9 | 27.5 | 19.0 | 0.17 | 1.16 |
| Young breeding sows and fattening pigs | 151.7 | 232 | 38.0 | 0.44 | 3.02 |
| Mature breeding sows and boars | 27.7 | 75.0 | 77.3 | 0.90 | 6.14 |

Latvia used country-specific data for nitrogen excretion from sheep, swine, horses, goats and poultry. In the last submission, calculations of N excretion for cattle have been based on IPCC methodology due to lack of national data for defined cattle sub-groups. After the European Union Effort sharing decision voluntary review in 2015, TERT considered possible underestimation of N excretion for swine and broilers. According TERT recommendations, Latvia changed the approach to report N excretion data for swine and poultry of estimations. Detailed information of estimated N excretion for cattle and swine sub-groups by IPCC methodology is represented in Table 5.25. During 2014-2016 Latvia makes efforts to update country-specific N excretion values based on national research data in the next inventory.

**Table 5.25 N excretion rates (Nex) for nitrous oxide emissions estimation of non-dairy cattle and swine subgroups, 2014**

| **Non-dairy cattle sub-groups** | | **Nex** (kg N animal$^{-1}$ yr$^{-1}$) |
|---|---|---|
| Young cattle under 1 year | dairy cattle calves | 15.7 |
| | beef cattle calves | 18.5 |
| Young cattle aged from 1 to 2 years | dairy cattle | 24.7 |
| | beef cattle | 26.4 |
| Mature non-dairy cattle over 2 years | bulls | 93.9 |
| | heifers | 49.4 |
| | other cows | 65.9 |
| **Swine sub-groups** | | |
| Piglets under 50 kg of weight (under 4 months) | | 5.0 |
| Young breeding sows and fattening pigs | | 13.0 |
| Mature breeding sows and boars | | 36.0 |

The total quantity of excreted N by livestock among MMS implemented in Latvia and estimation results of managed manure N available for application to managed soils is summarized in Table 5.26.

**Table 5.26 N excretion rates (Nex) per manure management system (MMS) and manure N available for application to managed soils (kg N animal$^{-1}$ yr$^{-1}$)**

| Year | Solid storage | Liquid systems | Pasture range and paddock | Anaerobic digester | Toal Nex per MMS | $N_{MMS\_Avb}$ |
|---|---|---|---|---|---|---|
| **1990** | 72083512 | 7453168 | 16052837 | NO | 95589518 | 51212483 |
| **1991** | 69386461 | 7223344 | 14992170 | NO | 91601975 | 49665605 |
| **1992** | 57427766 | 6020188 | 11238671 | NO | 74686625 | 41871815 |
| **1993** | 39773585 | 4236245 | 6560358 | NO | 50570188 | 29343556 |

| Year | Solid storage | Liquid systems | Pasture range and paddock | Anaerobic digester | Toal Nex per MMS | N MMS_Avb |
|---|---|---|---|---|---|---|
| **1994** | 34871568 | 4106517 | 5565753 | NO | 44543839 | 25896200 |
| **1995** | 34289070 | 4653114 | 5419438 | NO | 44361621 | 25596053 |
| **1996** | 32938641 | 4298093 | 5394751 | NO | 42631485 | 24597545 |
| **1997** | 30439812 | 4609528 | 5085023 | NO | 40134363 | 22818112 |
| **1998** | 27869971 | 4672334 | 4555195 | NO | 37097500 | 21109540 |
| **1999** | 24448036 | 4573689 | 3744870 | NO | 32766595 | 18751402 |
| **2000** | 24475347 | 4863909 | 3707678 | NO | 33046933 | 19047225 |
| **2001** | 24973043 | 6297529 | 3862869 | NO | 35133441 | 20263741 |
| **2002** | 24570666 | 6688075 | 3657265 | NO | 34916005 | 20190294 |
| **2003** | 23707518 | 6804851 | 3774626 | NO | 34286994 | 19666060 |
| **2004** | 22864638 | 6832109 | 3720662 | NO | 33417409 | 19215881 |
| **2005** | 22799788 | 7139076 | 4126192 | NO | 34065056 | 19347707 |
| **2006** | 22966652 | 7440917 | 4078219 | NO | 34485788 | 19669116 |
| **2007** | 23045353 | 8061401 | 4454149 | NO | 35560903 | 20088348 |
| **2008** | 21613718 | 8135214 | 4468507 | NO | 34217438 | 19225511 |
| **2009** | 20563609 | 8391709 | 4619252 | 20687 | 33595256 | 18606693 |
| **2010** | 20055630 | 7929003 | 4777726 | 1340483 | 34102842 | 17997611 |
| **2011** | 19550816 | 8031840 | 4883737 | 1661835 | 34128227 | 17836274 |
| **2012** | 19580180 | 6905556 | 5195731 | 3430828 | 35112295 | 17316215 |
| **2013** | 19314328 | 6634924 | 5651406 | 4568674 | 36169332 | 16998389 |
| **2014** | 19433878 | 7149125 | 6054822 | 4800176 | 37438000 | 16820900 |
| **Share of total % in 2014** | 51.9% | 19.1% | 16.2% | 12.8% | 100.0% | - |
| **2014 versus 2013** | +0.6% | +7.7% | +7.1% | +5.1% | +3.5% | -1.0% |
| **2014 versus 1990** | -73.0% | -4.1% | -62.3% | NA | -60.8% | -67.2% |

As explained in 2006 IPCC Guidelines, nitrous oxide emissions calculation should be referred to Tier 2 methodology; if country specific data is included in the estimation (country specific N excretion rates constitute Tier 2 methodology)[153].

The indirect nitrous oxide emissions from volatilisation of N in forms of $NH_3$ and Nox from manure management are estimated as:

$$N_2O_{G(mm)} = (N_{volatilization-MMS} \bullet EF_4)$$

*where:*

*$N_2O_{G(mm)}$ = indirect $N_2O$ emissions due to volatilization of N from Manure Management in the country, kg $N_2O$ $yr^{-1}$*
*$N_{volatilization-MMS}$ = amount of manure nitrogen that is lost due to volatilisation of $NH_3$ and Nox, kg N $yr^{-1}$*
*$EF_4$ = emission factor for $N_2O$ emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg $N_2O$-N (kg $NH_3$-N + Nox-N volatilised)$^{-1}$; default value 0.01 kg $N_2O$-N (kg $NH_3$-N +Nox-N volatilised)$^{-1}$ is used*

The indirect nitrous emissions from leaching and runoff of N from manure management systems are estimated as:

$$N_2O_{L(mm)} = (N_{leaching-MMS} \bullet EF_5)$$

where:

*$N_2O_{L(mm)}$ = indirect $_{N2O}$ emissions due to leaching and runoff from Manure Management in the country, kg $N_2O$ $yr^{-1}$*

*[153] 2006 IPCC Guidelines. Volume 4, Chapter 10, page 10.53*

*$N_{leaching-MMS}$ = amount of manure nitrogen that leached from manure management systems, kg N $yr^{-1}$*
*$EF_5$ = emission factor for $N_2O$ emissions from nitrogen leaching and runoff, kg $N_2O$-N/kg N leached and runoff (default value 0.0075 kg $N_2O$-N (kg N leaching/runoff)$^{-1}$*

The amount of manure nitrogen that is lost due to volatilisation of $NH_3$ and Nox is assigned to Tier 2 approach, according to TERT suggestion after European Union Effort sharing decision voluntary review in 2015. Tier 2 methodology to calculate N that is lost due to volatilisation of $NH_3$ and Nox from the livestock buildings and manure storage facilities is adopted from EMEP/EEA 2013[154].

Risks related to the agricultural point source pollution of surface waters by N leaching and run-off from manure storages can be consider as significant, because the number of farms with high livestock number (more than 250 animal units), especially from pig-breeding and poultry farming branches, increasing in last years; besides many of them are located in the Nitrate Vulnerable Zone with short distance to the water bodies of national importance. Results of long-term agricultural runoff monitoring show that in the catchment basin where the large livestock farms as potential point source pollution are located, the concentrations of nitrogenous compounds are characterized by large dispersion and high maximum concentrations. Based on the measures taken at the national level in order to reduce the pollution of surface waters caused by agricultural production, the long-term agricultural point source pollution monitoring observations indicate that concentrations of pollutants show negative trends, but are still should be taken into account[155]. Values of $Frac_{Leach}$ is based on expert judgment who are involved in national agricultural point source monitoring activities under Agricultural Runoff programme. In 1990-2004, $Frac_{Leach}$ is set to 10% by reducing the value to 1% for slurry storages and 5% to solid storages till 2014. The amount of manure N that is leached from manure management systems is derived from 2006 IPCC Guidelin*es*, Equation 10.28[156].

### 5.3.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6. The uncertainty of the manure management system usage data depends on the characteristics of each country's livestock industry and how information on manure management is collected. 2006 IPCC Guidelines show that for one type of management system, the uncertainty associated with management system usage data can be 10% or less. However, for countries where there is a wide variety of management systems, the uncertainty range in management system usage data can be much higher, in the range of 25% to 50%, depending on the availability of reliable and representative survey data that differentiates animal populations by system usage[157]. For Latvia uncertainty of 25% is set. The uncertainty range for the default emission factors is estimated to be +30%. Improvements achieved by Tier 2 methodologies are evaluated to

*[154] EMEP/EEA Air pollutant emission inventory guidebook. (2013) 3.B Manure management. European Environment Agency, page 18*
*[155] Berzina L. (2014) Analysis of Point Source Pollution from Agricultural Production Influence on Surface Water Quality in Highly Vulnerable Zones. Summary of the Thesis for Doctoral Degree in Engineering Sciences, Environmental Science branch, Environmental Engineering subbranch. 91 p.*
*[156] 2006 IPCC Guidelines. Volume 4, Chapter 10, Equation 10.28, page, 10.56*
*[157] 2006 IPCC Guidelines. Volume 4, Chapter 10, page 10.50*

reduce uncertainty ranges in the emission factors to +20%. IPCC expert judgment shows that uncertainty ranges for the default N excretion rates are estimated at about +50%[158]. Latvia uses country specific values, therefore uncertainty for N excretion rates are reduced to 25%.

### 5.3.4 Category-specific QA/QC and verification

**Activity data check.** The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. General QC procedures including quality checks related to calculations, data processing, completeness, and documentation were used during the inventory. Defined manure management systems in the inventory is consistent with definitions that are presented in 2006 IPCC Guidelines Table 10.18[159]. Latvia uses country specific methodology to determine distribution of manure management systems that is available in scientific literature[160].

**Review of emission factors.** Country-specific emission factors were compared with IPCC defaults. Emission factors were chosen as for cool climate region by average annual temperature ≤10°C. Review results are presented in the chapter above.

Latvia uses country specific nitrogen excretion rates[161], according to the latest research results. Calculated and measured nitrogen excretion rates are compared with other countries inventory data and default factors. No significant differences were found for rates used for inventory that are within the range of values reported in other EU countries.

### 5.3.5 Category-specific recalculations

For 2016 submission, recalculations of emissions from manure management for period 1900-2014 are done based on implementation of new approach to calculate manure management system distribution. Nitrogen excretion values are changed for poultry and swine. Emissions from swine are calculated within three age subcategories, comparing to the previous submission, manure management emissions also is split down for poultry subgroups. MCF value 2 for anaerobic digester is implemented in the inventory, according to TERT review results. Also a new animal category as deer is included in the inventory.

Recalculations of MMS are done according to outcomes of pre-defined project "Development of the National System for Greenhouse Gas Inventory and Reporting on Policies, Measures and Projections" under 2009 – 2014 EEA Grants Programme National Climate Policy. Main differences caused by implementation of new methodology to determine MMS should be tended to liquid manure system, which was found as no typical for cattle in Latvia. Significantly, the share of pasture, range and paddock was reduced for all livestock groups, except beef cattle. Most of the large livestock farms refuse grazing to keep high productivity of animals and arrange resources in economically feasible way.

[158] *2006 IPCC Guidelines.Volume 4, Chapter 10, page 10.66*
[159] *2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.18, page 10.49*
[160] *Priekulis J., Āboltiņš A. (2015) Calculation Methodology for Cattle Manure Management Systems Based on the 2006 IPCC Guidelines. Proceedings of the 25th NJF Congress Nordic View to Sustainable Rural Development. Riga, pp.274-280*
[161] *Fertiliser Recommendations for Agricultural Crops (2013) Ed.A. Karklins and A.Ruza. Jelgava:LLU, 55 p.*

### 5.3.6 Category-specific planned improvements

Implementation of country specific nitrogen excretion values for all livestock groups based on latest research activities. Revision of MCF value for anaerobic digester.

## *5.4 AGRICULTURAL SOILS (CRF 3.D)*

### 5.4.1 Category description

In the 2006 IPCC Guidelines, direct and indirect emissions of nitrous oxide from managed soils are estimated separately. The following N sources are included in the inventory for estimating direct nitrous oxide emissions from managed soils:

- synthetic N fertilizers ($F_{SN}$);
- organic N fertilizers (e.g., animal manure, compost, sewage sludge, digestate) ($F_{ON}$);
- urine and dung N deposited on pasture, range and paddock by grazing animals ($F_{PRP}$);
- N in crop residues (above-ground and below-ground), including from N-fixing crops and from forages during pasture renewal ($F_{CR}$);
- drainage/management of organic soils ($F_{OS}$).

Indirect nitrous oxide emissions from managed soils are determined for volatilization and leaching processes. Indirect nitrous oxide emissions included in the inventory are reported in Table 5.27.

**Table 5.27 Reported emissions under the subcategory Agricultural Soils**

| CRF | Source | Emissions reported | Level |
|---|---|---|---|
| 3.D 1.1 | Inorganic N fertilizers | $N_2O$ | Tier 1 |
| 3.D 1.2.a | Animal manure applied to soils | $N_2O$ | Tier 1 |
| 3.D 1.2.b | Sewage sludge applied to soils | $N_2O$ | Tier 1 |
| 3.D 1.2.c | Other organic fertilizer applied to soils | $N_2O$ | Tier 1 |
| 3.D 1.3 | Urine and dun deposited on soils | $N_2O$ | Tier 1 |
| 3.D 1.4 | Crop residues | $N_2O$ | Tier 1 |
| 3.D 1.5 | Mineralization/immobilization associated with loss/gain of soil organic matter | NO | NA |
| 3.D 1.6 | Cultivation of organic soils | $N_2O$ | Tier 1 |
| 3.D 1.7 | Other | NO | NA |
| 3.D 2.1 | Atmospheric deposition | $N_2O$ | Tier 1 |
| 3.D 2.2 | Nitrogen leaching and run-off | $N_2O$ | Tier 1 |

Nitrous oxide emission from managed soils was 5.45 kt in 2014; which is 2.7% more than in 2013. In general, emission has decreased in 2014 by 30.5% comparing with 1990. The main reason for that was decreasing of all livestock numbers that affected the amount of nitrogen excreted annually to soil and low consumption of fertilizers. However, in 2014 nitrous oxide emission increased by 0.14 kt or 2.7% compared with 2013 (Table 5.28). The main reason of the increase of emission absolute number is the growing demand of synthetic fertilizers in the latest years.

In 2014, total nitrous oxide emission from managed soils originated as 87.9% from direct sources. Indirect nitrous oxide emission from volatilization formed 3.5% and from leaching – 8.6% of the nitrous oxide total emission (Table 5.28).

**Table 5.28 Nitrous oxide emissions from Managed Soils, 1990-2014 (kt)**

| Year | $N_2O$ direct emission | $N_2O$ indirect emission from atmospheric deposition | $N_2O$ indirect emission from leaching and run-off | Total |
|---|---|---|---|---|
| **1990** | 6.59 | 0.42 | 0.85 | 7.85 |
| **1991** | 6.19 | 0.38 | 0.76 | 7.33 |
| **1992** | 5.10 | 0.27 | 0.53 | 5.90 |
| **1993** | 4.29 | 0.18 | 0.36 | 4.83 |
| **1994** | 3.96 | 0.14 | 0.29 | 4.40 |
| **1995** | 3.60 | 0.12 | 0.21 | 3.93 |
| **1996** | 3.67 | 0.12 | 0.23 | 4.02 |
| **1997** | 3.72 | 0.12 | 0.25 | 4.08 |
| **1998** | 3.64 | 0.11 | 0.23 | 3.99 |
| **1999** | 3.51 | 0.10 | 0.21 | 3.82 |
| **2000** | 3.58 | 0.11 | 0.23 | 3.91 |
| **2001** | 3.76 | 0.13 | 0.27 | 4.16 |
| **2002** | 3.69 | 0.12 | 0.25 | 4.06 |
| **2003** | 3.81 | 0.13 | 0.28 | 4.23 |
| **2004** | 3.78 | 0.13 | 0.28 | 4.18 |
| **2005** | 3.92 | 0.14 | 0.31 | 4.38 |
| **2006** | 3.92 | 0.14 | 0.31 | 4.38 |
| **2007** | 4.05 | 0.15 | 0.34 | 4.55 |
| **2008** | 4.08 | 0.15 | 0.35 | 4.58 |
| **2009** | 4.18 | 0.16 | 0.37 | 4.70 |
| **2010** | 4.29 | 0.17 | 0.38 | 4.84 |
| **2011** | 4.33 | 0.17 | 0.38 | 4.88 |
| **2012** | 4.60 | 0.18 | 0.44 | 5.21 |
| **2013** | 4.68 | 0.18 | 0.45 | 5.31 |
| **2014** | 4.80 | 0.19 | 0.47 | 5.45 |
| **Share of total % in 2014** | 87.9% | 3.5% | 8.6% | 100.0% |
| **2014 versus 2013** | +2.5% | +3.3% | +4.8% | +2.7% |
| **2014 versus 1990** | -27.2% | -54.6% | -44.8% | -30.5% |

In 2014, managed organic soils formed the major part of total direct emissions (54.8%), following by emission from synthetic fertilizers (23.9%), crop residues (11.6%), animal manure applied to soils (5.5%), urine and dung deposited on pasture (3.8%), and other organic N additions applied to soils (Table 5.29). Overall, nitrous oxide emissions from application of other organic fertilizer (except manure), pastures, crop residues and synthetic N fertilizer increasing most rapidly in last years. This could be explained by the fact of increased number of beef cattle grazing on pastures and expanding of sown area. During last two inventory years the production of beef increased by 5.8%. The significant growth in harvested production was mainly affected by increase of the cereal crop area. According to CSB information, in 2014 the area of cereal cropland increase by 12.2% compared to 2013. Use of mineral fertilizer N per one ha of sown area continued to grow from 61 kg in 2013 to 63 kg in 2014 and comprised in 49.7% of straight nitrogen mineral fertilizer amount applied to soils[162]. Increasing use of other organic fertilizers could be linked to expansion of anaerobic digestion of biomass and applying digestate to soil.

[162] *Agriculture in Latvia. Collection of statistical data. Central Statistical Bureau of Latvia, 2015*

**Table 5.29 Nitrous oxide emissions from N inputs to managed soils, 1990-2014 (kt)**

| Year | $F_{SN}$ | $F_{ON}$ (animal manure) | $F_{ON}$ (sludge) | $F_{ON}$ (other) | $F_{PRP}$ | $F_{CR}$ | $F_{OS}$ |
|---|---|---|---|---|---|---|---|
| 1990 | 2.06 | 0.80 | NO | NO | 0.50 | 0.64 | 2.57 |
| 1991 | 1.77 | 0.78 | NO | NO | 0.47 | 0.61 | 2.58 |
| 1992 | 1.04 | 0.66 | NO | NO | 0.35 | 0.48 | 2.58 |
| 1993 | 0.62 | 0.46 | NO | NO | 0.20 | 0.43 | 2.57 |
| 1994 | 0.46 | 0.41 | NO | NO | 0.17 | 0.35 | 2.57 |
| 1995 | 0.18 | 0.40 | NO | NO | 0.17 | 0.28 | 2.57 |
| 1996 | 0.23 | 0.39 | NO | NO | 0.17 | 0.33 | 2.56 |
| 1997 | 0.30 | 0.36 | NO | NO | 0.16 | 0.34 | 2.55 |
| 1998 | 0.31 | 0.33 | NO | NO | 0.14 | 0.32 | 2.54 |
| 1999 | 0.30 | 0.29 | NO | NO | 0.12 | 0.27 | 2.53 |
| 2000 | 0.36 | 0.30 | NO | NO | 0.11 | 0.28 | 2.52 |
| 2001 | 0.50 | 0.32 | 0.024 | NO | 0.12 | 0.29 | 2.51 |
| 2002 | 0.43 | 0.32 | 0.018 | NO | 0.11 | 0.30 | 2.50 |
| 2003 | 0.59 | 0.31 | 0.007 | NO | 0.12 | 0.29 | 2.50 |
| 2004 | 0.55 | 0.30 | 0.006 | NO | 0.11 | 0.31 | 2.49 |
| 2005 | 0.64 | 0.30 | 0.005 | NO | 0.13 | 0.37 | 2.48 |
| 2006 | 0.67 | 0.31 | 0.007 | NO | 0.12 | 0.34 | 2.47 |
| 2007 | 0.72 | 0.32 | 0.006 | NO | 0.14 | 0.41 | 2.46 |
| 2008 | 0.75 | 0.30 | 0.004 | NO | 0.14 | 0.44 | 2.45 |
| 2009 | 0.82 | 0.29 | 0.005 | NO | 0.14 | 0.44 | 2.49 |
| 2010 | 0.94 | 0.28 | 0.007 | 0.008 | 0.14 | 0.39 | 2.52 |
| 2011 | 0.94 | 0.28 | 0.007 | 0.003 | 0.15 | 0.40 | 2.55 |
| 2012 | 1.02 | 0.27 | 0.006 | 0.007 | 0.16 | 0.54 | 2.58 |
| 2013 | 1.10 | 0.27 | 0.006 | 0.009 | 0.17 | 0.52 | 2.62 |
| 2014 | 1.15 | 0.26 | 0.005 | 0.011 | 0.18 | 0.56 | 2.63 |
| **Share of total % in 2014** | 23.9% | 5.5% | 0.1% | 0.2% | 3.8% | 11.6% | 54.8% |
| **2014 versus 2013** | +4.6% | -1.0% | -8.3% | +24.2% | +7.1% | +7.9% | +0.6% |
| **2014 versus 1990** | -44.5% | -67.2% | NA | NA | -63.2% | -13.7% | +2.2% |

$F_{SN}$ = synthetic N fertilizer, $F_{ON}$ = organic N additions, $F_{PRP}$ = urine and dang N deposited on pasture, $F_{CR}$ = N in crop residues, $F_{OS}$ = managed organic soil in grassland and cropland.

### 5.4.2 Methodological issues

For estimation of nitrous oxide emissions from managed soils the Tier 1 methodology was used. Direct nitrous oxide emissions from agricultural soils have been calculated using the following equation according to 2006 IPCC Guidelines[163] :

$$N_2O_{Direct} - N = N_2O - N_{N\,inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

*where:*

$$N_2O - N_{N\,inputs} = (F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \cdot EF_1$$

$$N_2O - N_{OS} = \left(F_{OS,CG,Temp} \cdot EF_{2G,Temp}\right)$$

$$N_2O - N_{PRP} = \left[\left(F_{PRP,CPP} \cdot EF_{3PRP,CPP}\right) + \left(F_{PRP,SO} \cdot EF_{3PRP,SO}\right)\right]$$

[163] *2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.1, page 11.7*

*where:*
*$N_2O_{Direct}$ –N = annual direct $N_2O$–N emissions produced from managed soils, kg $N_2O$–N $yr^{-1}$*
*$N_2O$–$N_{N\ inputs}$ = annual direct $N_2O$–N emissions from N inputs to managed soils, kg $N_2O$–N $yr^{-1}$*
*$N_2O$–$N_{OS}$ = annual direct $N_2O$–N emissions from managed organic soils, kg $N_2O$–N $yr^{-1}$*
*$N_2O$–$N_{PRP}$ = annual direct $N_2O$–N emissions from urine and dung inputs to grazed soils, kg $N_2O$–N $yr^{-1}$*
*$F_{SN}$ = annual amount of synthetic fertiliser N applied to soils, kg N $yr^{-1}$*
*$F_{ON}$ = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N $yr^{-1}$*
*$F_{CR}$ = annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N $yr^{-1}$*
*$F_{SOM}$ = annual amount of N in mineral soils that is mineralised, in association with loss of soils C from soils organic matter as a result of changes to land use or management, kg N $yr^{-1}$*
*$F_{OS}$ = annual area of managed/drained organic soils in grasslands and croplands, ha*
*$F_{PRP}$ = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N $yr^{-1}$*
*$EF_1$ = emission factor for $N_2O$ emissions from N inputs, kg $N_2O$–N $kg^{-1}$ N input*
*$EF_2$ = emission factor for $N_2O$ emissions from drained/managed organic soils, kg $N_2O$–N $ha^{-1}$ $yr^{-1}$*
*$EF_{3PRP}$ = emission factor for $N_2O$ emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg $N_2O$–N/kg N input*

### *Inorganic N fertilizers: CRF 3.D 1.1*

Annual amount of the synthetic fertilizer N is one of the parameters to estimate direct nitrous oxide emission from N inputs to managed soils. Data of inorganic fertiliser N applied to soils are provided by CSB of Latvia. Input values for direct nitrous oxide emission calculation from inorganic N fertilizers are represented in Table 5.35.

### *Organic N fertilizers: CRF 3.D 1.2*

Amount of the organic N fertiliser ($F_{ON}$) applied to soils is calculated using methodology represented in 2006 IPCC Guidelines[164]. This includes applied to soils animal manure, sewage, compost, as well as other organic amendments of regional importance to agriculture:

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$$

*where:*
*$F_{ON}$ = total annual amount of organic N fertiliser applied to soils other than by grazing animals, kg N $yr^{-1}$*
*$F_{AM}$ = annual amount of animal manure N applied to soils, kg N $yr^{-1}$*
*$F_{SEW}$ = annual amount of total sewage N that is applied to soils, kg N $yr^{-1}$*
*$F_{COMP}$ = annual amount of total compost N applied to soils, kg N $yr^{-1}$*
*$F_{OOA}$ = annual amount of other organic amendments used as fertiliser, kg N $yr^{-1}$*

Data on the amount of sewage sludge applied to managed soils are provided by LEGMC, other data of organic N fertiliser applied to soils are obtained from CSB. Application of sewage sludge as fertilizer is relatively small in Latvia. Amounts of sewage composts are not included in the calculations. Other organic amendments used as fertiliser mainly refer to digestate. Amount of nitrogen in sewage sludge, digestate and composts are calculated based on agriculture research results done by Latvia University of Agriculture scientists,[165] other research projects [166] and Latvia University of Agriculture expert judgement. Statistics

[164] *2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.3, page 11.12*
[165] *Gemste I., Vucāns A. (2010) Notekūdeņu dūņas. Jelgava, LLU, 276 lpp.*
[166] *Litiņa I. (2013) Digestāta kā mēslošanas līdzekļa efektivitātes novērtējums kukurūzas sējumā. Zinātniski praktiskā konference LAUKSAIMNIECĪBAS ZINĀTNE VEIKSMĪGAI SAIMNIEKOŠANAI. Jelgava, LLU, 206-209 lpp.*

of different types of organic N fertilisers applied to soils are limited in Latvia. Available data are represented in Table 5.30.

**Table 5.30 Statistics of organic N fertilisers applied to soils, 2001-2014**

| Year | Sewage sludge applied to managed soils, t dry matter | Composts applied to managed soils, thousand t | Other organic N (digestate) applied to managed soils thousand t |
|---|---|---|---|
| **2001** | 30946.7 | NO | NO |
| **2002** | 22513.9 | NO | NO |
| **2003** | 9230.89 | NO | NO |
| **2004** | 7683.7 | NO | NO |
| **2005** | 6545.5 | NO | NO |
| **2006** | 8936.4 | NO | NO |
| **2007** | 8131.6 | NO | NO |
| **2008** | 5255.2 | NO | NO |
| **2009** | 6686.9 | NO | NO |
| **2010** | 9306.5 | 95.5 | 3.7 |
| **2011** | 8759.5 | 39.9 | 6.1 |
| **2012** | 7472.6 | 62.2 | 82.5 |
| **2013** | 7479.2 | 40.4 | 289.9 |
| **2014** | 6861.2 | 36.2 | 413.9 |
| **2014 versus 2013** | -8.3% | -10.4% | +42.8% |

Animal manure N ($F_{AM}$) emits from agricultural soil through manure application to fields as an organic fertilizer. Calculation of emissions from nitrogen input through application of animal manure is done according to 2006 IPCC Guidelines[167]:

$$F_{AM} = N_{MMS\,Avb} \cdot [1 - (Frac_{FEED} + Frac_{FUEL} + Frac_{CNST})]$$

*where:*
*$F_{AM}$ = annual amount of animal manure N applied to soils, kg N $yr^{-1}$*
*$N_{MMS\,Avb}$ = amount of managed manure N available for soil application, feed, fuel or construction, kg N$yr^{-1}$*
*$Frac_{FEED}$ = fraction of managed manure used for feed*
*$Frac_{FUEL}$ = fraction of managed manure used for fuel*
*$Frac_{CNST}$ = fraction of managed manure used for construction*

Total annual amount of the managed manure N available for soil application ($F_{MMS\_Avb}$) is determined by 2006 IPCC Guidelines (Chapter 10.5.4) according to the directions of estimation of N lost from manure management systems to final application on managed soils. Calculation of $F_{MMS\_Avb}$ is done by fully adopted IPCC methodology (2006 IPCC Guidelines, Volume 4, Chapter 10, Equation 10.34, p.10.65; fallowing by default values for total N loss from manure management represented in Table 10.23, p.10.67). There is no data available on the fraction of manure being used as feed, fuel or material of construction therefore $F_{AM}$ is considered to be equal to $N_{MMS\ Abv.}$ Total annual amount of managed manure N available for soil application is determined under CRF category 3B Manure management and is represented in Table 5.26.

### *Urine and Dung Deposited by Grazing Animals: CRF 3.D 1.3*

The term $F_{PRP}$ refers to the annual amount of N deposited on pasture, range and paddock soils by grazing animals. $F_{PRP}$ is estimated using 2006 IPCC Guidelines from the number of

[167] *2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.4, page 11.13*

animals in each livestock species/category T($N_{(T)}$), the annual average amount of N excreted by each livestock species/category T ($Nex_{(T)}$), and the fraction of this N deposited on pasture, range and paddock soils by each livestock species/category T ($MS_{(T,PRP)}$)[168]:

$$F_{PRP} = \sum_{T} \left[ \left( N_{(T)} \cdot Nex_{(T)} \right) \cdot MS_{(T,PRP)} \right]$$

Total annual amount of N deposited on pasture, range and paddock soils by grazing animals is determined under CRF category 3B Manure management and is represented in Table 5.26.

Total annual amount of N deposited on pasture, range and paddock soils separately for two groups: $F_{PRP,\ CPP}$ (cattle, poultry and swine) and $F_{PRP,\ SO}$ (other livestock), according to directions of nitrous oxide emissions estimation by IPCC is summarized in Table 5.35.

***Crop residues: CRF 3.D 1.4***

The annual production of the amount of crop residue N ($F_{CR}$) is estimated based on 2006 IPCC Guidelines Tier 1 methodology[169]:

$$F_{CR} = \sum_{T} \left\{ \begin{array}{c} Crop_{(T)} \cdot Frac_{Renew\,(T)} \cdot \\ \left[ \left( Area_{(T)} - Area\ burnt_{(T)} \cdot C_f \right) \cdot R_{AG\,(T)} \cdot N_{AG(T)} \cdot \left( 1 - Frac_{Remove\,(T)} \right) + Area_{(T)} \cdot R_{BG(T)} \cdot N_{BG(T)} \right] \end{array} \right\}$$

*where:*
*$F_{CR}$ = annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually, kg N yr$^{-1}$*
*$Crop_{(T)}$ = harvested annual dry matter yield for crop T, kg d.m. ha$^{-1}$*
*$Area_{(T)}$ = total annual area harvested of crop T, ha yr$^{-1}$*
*Area burnt $_{(T)}$ = annual area of crop T burnt, ha yr$^{-1}$*
*$C_f$ = combustion factor*
*$Frac_{Renew\,(T)}$ = fraction of total area under crop T*
*$R_{AG(T)}$ = ratio of above-ground residues dry matter to harvested yield for crop T*
*$N_{AG(T)}$ = N content of above-ground residues for crop T, kg N (kg d.m.)$^{-1}$*
*$Frac_{Remove(T)}$ = fraction of above-ground residues of crop T removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)$^{-1}$*
*$R_{BG(T)}$ = ratio of below-ground residues to harvested yield for crop T, kg d.m. (kg d.m.)$^{-1}$*
*$N_{BG(T)}$ = N content of below-ground residues for crop T, kg N (kg d.m.)$^{-1}$*
*T = crop or forage type.*

Correction factor to estimate dry matter yields ($Crop_{(T)}$) is determined as[170]:

$$Crop_{(T)} = Yield\ Fresh_{(T)} \cdot DRY$$

*where:*
*$Crop_{(T)}$ = harvested dry matter yield for crop T, kg d.m. ha$^{-1}$*
*Yield $Fresh_{(T)}$ = harvested fresh yield for crop T, kg fresh weight ha$^{-1}$*
*DRY = dry matter fraction of harvested crop T, kg d.m. (kg fresh weight)$^{-1}$*

Mainly default and international input data were used to estimate N that is returned to soils by crop residues, except data of crop production (area and yield) that originates from CSB Database. Dry matter fractions of harvested crop are collected as combination of IPCC default and national values, corrected by expert judgement (Table 5.31).

*[168] 2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.5, page 11.13*
*[169] 2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.6, page 11.14*
*[170] 2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.7, page 11.15*

**Table 5.31 Dry matter fraction (DRY) of harvested crop (kg fresh weight$^{-1}$)**

| Crop | DRY |
|---|---|
| Wheat | 0.86 |
| Barley, | 0.86 |
| Triticale | 0.86 |
| Oats | 0.86 |
| Rye | 0.86 |
| Buckwheat | 0.86 |
| Pulses | 0.91 |
| Fodder roots | 0.20 |
| Potatoes | 0.22 |
| Vegetable | 0.22 |
| Maize for silage and forage | 0.30 |
| Crops for green feed and silage | 0.17 |
| Perennial grass | 0.90 |
| Rape | 0.91 |
| Flax | 0.91 |

Calculations on annual amount of N in crop residues are done based on default factors represented in 2006 IPCC Guidelines[171].All data sources to calculate N that is returned to soil by crop residues are represented in Table 5.32.

**Table 5.32 Data sources for estimation of N in crop residues**

| Input parameter | Data source |
|---|---|
| Crop harvested yield | Central Statistical Bureau |
| Crop harvested area | Central Statistical Bureau |
| Burnt crop area | NO |
| $Frac_{Renew}$ | Expert judgement, IPCC default |
| $Frac_{Remove}$ | Expert judgement, IPCC default |
| $AG_{DM}$ | 2006 IPCC, Table 11.2 |
| $N_{AG}$ | 2006 IPCC, Table 11.2 |
| $R_{BG-BIO}$ | 2006 IPCC, Table 11.2 |
| $N_{BG}$ | 2006 IPCC, Table 11.2 |
| $R_{AG}$ | 2006 IPCC, Page 11.4 |
| $R_{GB}$ | 2006 IPCC, Page 11.4 |

There is no field burning of agricultural residues observed in Latvia and area burnt is set to zero. It is estimated by Latvia University of Agriculture expert that approximately 20% of above-ground residues of all main crops (wheat, outs, barley and rye) and 80% of rape are removed annually for purposes such as feeding, bedding and construction ($Frac_{Remove}$). No other data to estimate the fraction of above-ground residues of crop removed for purposes such as feed, bedding and construction is available. According to expert judgment, perennial grass is renewed on average every 4 years. For annual crops $Frac_{Renew}$ 1 was set, as also proposed in the 2006 IPCC Guidelines. Final results of estimation of annual amount of N in crop residues are available in Table 5.35.

[171] *2006 IPCC Guidelines. Volume 4, Chapter 11, Table 11.2, page 11.17*

### *Mineralization/immobilization associated with loss/gain of soil organic matter: CRF 3.D 1.5*

Average annual loss of soils carbon due to land use or management systems change was obtained from LULUCF sector. The net annual amount of N mineralised in mineral soils as a result of loss soil carbon stock change due land use change is accounted under LULUCF sector and reported under activities listed in paragraph 3.3 of the Kyoto protocol (deforestation). The net annual amount of N mineralised in mineral soils as a result of loss soil carbon stock change due to management activities, including conversion of cropland to grassland, is assumed to be NO, because of the net removals of $CO_2$ in soil in cropland and grassland due to management activities.

### *Cultivation of organic soils: CRF 3.D 1.6*

Data on annual area of managed organic soils are adopted from LULUCF sector and prepared by Latvian State Forest Research Institute *Silava.* Nitrous oxide emissions from cultivated organic soils have been calculated with the IPCC methodology by dividing the area into grassland and cropland and using emission factors from IPCC Wetlands Supplement[172] to reach consistent reporting of emissions with LULUCF sector. Tier 1 methodology[173] for calculations is used and emission coefficients are summarized in Table 5.34. The area of cultivated organic soils is shown in (Table 5.33).

**Table 5.33 Area of cultivated organic soil, 1990-2014 (ha)**

| Year | Organic soil in cropland | Organic soil in grassland | Total |
|---|---|---|---|
| **1990** | 95759.1 | 41348.7 | 137107.8 |
| **1991** | 95833.3 | 41350.0 | 137183.3 |
| **1992** | 95993.8 | 41141.7 | 137135.6 |
| **1993** | 96063.6 | 40947.5 | 137011.1 |
| **1994** | 96113.5 | 40877.8 | 136991.3 |
| **1995** | 96151.9 | 40591.2 | 136743.1 |
| **1996** | 95903.3 | 40274.9 | 136178.1 |
| **1997** | 95658.1 | 40020.5 | 135678.6 |
| **1998** | 95495.8 | 39639.5 | 135135.2 |
| **1999** | 95220.8 | 39446.7 | 134667.5 |
| **2000** | 95011.0 | 39100.9 | 134111.9 |
| **2001** | 94658.9 | 38778.7 | 133437.6 |
| **2002** | 94438.0 | 38452.3 | 132890.3 |
| **2003** | 94193.1 | 38300.5 | 132493.5 |
| **2004** | 93880.0 | 38016.1 | 131896.2 |
| **2005** | 93553.4 | 37856.4 | 131409.8 |
| **2006** | 93213.3 | 37870.3 | 131083.6 |
| **2007** | 92859.6 | 37907.8 | 130767.4 |
| **2008** | 92492.4 | 37846.0 | 130338.4 |
| **2009** | 92571.1 | 39905.0 | 132476.1 |
| **2010** | 92649.9 | 41968.5 | 134618.4 |
| **2011** | 92718.6 | 44036.5 | 136755.1 |
| **2012** | 92787.4 | 46109.1 | 138896.5 |

[172] *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. Chapter 2, Table 2.5, page 2.33*

[173] *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. Chapter 2, , page 2.31*

| Year | Organic soil in cropland | Organic soil in grassland | Total |
|---|---|---|---|
| **2013** | 92846.1 | 48186.4 | 141032.5 |
| **2014** | 92938.1 | 49038.1 | 141976.2 |
| **Share of total % in 2014** | 65.5% | 34.5% | 100.0% |
| **2014 versus 2013** | +0.1% | +1.8% | +0.7% |
| **2014 versus 1990** | -2.9% | +18.6% | +3.6% |

### *Atmospheric deposition: CRF 3.D 2.1*

The nitrous oxide emission from atmospheric deposition of N volatilised from managed soil is estimated using 2006 IPCC Guidelines[174]:

$$N_2O_{(ATD)} - N = \left[(F_{SN} \cdot Frac_{GASF}) + \left((F_{ON} + F_{PRP}) \cdot Frac_{GASM}\right)\right] \cdot EF_4$$

*where:*

*$N_2O_{(ATD)}$-N = annual amount of $N_2O$–N produced from atmospheric deposition of N volatilised from managed soils, kg $N_2O$–N $yr^{-1}$*

*$F_{SN}$ = annual amount of synthetic fertiliser N applied to soils, kg N $yr^{-1}$*

*$Frac_{GASF}$ = fraction of synthetic fertiliser N that volatilises as $NH_3$ and Nox, kg N volatilised (kg of N applied)$^{-1}$*

*$F_{ON}$ = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N $yr^{-1}$*

*$F_{PRP}$ = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N $yr^{-1}$*

*$Frac_{GASM}$ = fraction of applied organic N fertiliser materials ($F_{ON}$) and of urine and dung N deposited by grazing animals ($F_{PRP}$) that volatilises as $NH_3$ and Nox, kg N volatilised (kg of N applied or deposited)$^{-1}$*

*$EF_4$ = Emission factor for $N_2O$ emissions from atmospheric deposition of N on soils and water surfaces, kg $N_2O$-N/kg $NH_3$-N and Nox-N emitted*

Results of estimation are available in Table 5.28.

### *Nitrogen leaching and run-off: CRF 3.D 2.2*

The nitrous oxide emission from nitrogen loss from agricultural soils through leaching and runoff is estimated as shown in 2006 IPCC Guidelines[175]:

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \cdot Frac_{LEACH-(H)} \cdot EF_5$$

*where:*

*$N_2O_{(L)}$–N = annual amount of $N_2O$–N produced from leaching and runoff, kg $N_2O$–N $yr^{-1}$*

*$F_{CR}$ = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, kg N $yr^{-1}$*

*$F_{SOM}$ = annual amount of N mineralised in mineral soils, kg N $yr^{-1}$*

*$Frac_{LEACH-(H)}$ = Fraction of N input that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$*

*$EF_5$ = emission factor for $N_2O$ emissions from N leaching and runoff, kg $N_2O$–N (kg N leached and runoff)$^{-1}$*

The results of estimation of nitrous oxide emission from nitrogen loss from agricultural soils through leaching and runoff are available in Table 5.28. All emission coefficients and fractions for direct and indirect emissions estimation from managed soils are summarized in Table 5.34.

*[174] 2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.9, page 11.21*
*[175] 2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.10, page 11.2*

**Table 5.34 Default emission, volatilization and leaching factors for direct and indirect nitrous oxide emissions calculation**

| Factor | Value | Uncertainty range |
|---|---|---|
| $EF_1$ for N additions from mineral fertilizers, organic amendments and crop residues [kg $N_2O$–N (kg N)$^{-1}$] | 0.01 | 0.003 – 0.03 |
| $EF_{2\ C}$, for boreal and temperate drained organic cropland soil (kg$N_2O$–N ha$^{-1}$)<br>$EF_{2\ G}$, for boreal drained organic grassland soils (kg$N_2O$–N ha$^{-1}$) | 13<br>9.5 | 8.2 – 18<br>4.6 – 14 |
| $EF_{3PRP,\ CPP}$ for cattle (dairy, non dairy), poultry and pigs [kg $N_2O$–N (kg N)$^{-1}$] | 0.02 | 0.007 – 0.06 |
| $EF_{3PRP,\ SO}$ for cattle (dairy, non dairy), poultry and pigs [kg $N_2O$–N (kg N)$^{-1}$] | 0.01 | 0.003 – 0.03 |
| $EF_4$ [N volatilization and re-deposition], kg $N_2O$–N [kg $NH_3$–N + $NO_X$–volatilized] | 0.010 | 0.002 – 0.05 |
| $EF_5$ (leaching/runoff), kg $N_2O$–N [kg N leaching/runoff] | 0.0075 | 0.0005 -0.025 |
| $Frac_{GASF}$ (Volatilization from synthetic fertilizer),<br>(kg $NH_3$–N + Nox–N) [kg N applied]$^{-1}$ | 0.10 | 0.03 – 0.3 |
| $Frac_{GASM}$ (Volatilization from all organic N fertilizers applied , and dung and urine deposited by grazing animals), [kg $NH_3$–N + Nox–N]<br>[kg N applied or deposited]$^{-1}$ | 0.20 | 0.05 – 0.5 |
| $Frac_{LEACH-(H)}$,N losses by leaching/runoff [kg N ] | 0.30 | 0.1 – 0.8 |

Summary of input variables for direct nitrous oxide emission estimation according to methodology explained above are provided in Table 5.35.

**Table 5.35 Input values for direct nitrous oxide emission calculations from managed soils, 1990-2014**

| Year | $F_{SN}$ | $F_{OM}$ | $F_{PRP,\ CPP}$ | $F_{PRP,\ SO}$ | $F_{CR}$ |
|---|---|---|---|---|---|
| **1990** | 131400.0 | 51212.5 | 15683.2 | 369.6 | 41024.0 |
| **1991** | 112400.0 | 49665.6 | 14602.5 | 389.6 | 38510.1 |
| **1992** | 66000.0 | 41871.8 | 10881.1 | 357.6 | 30690.2 |
| **1993** | 39700.0 | 29343.6 | 6278.2 | 282.1 | 27195.5 |
| **1994** | 29000.0 | 25896.2 | 5315.0 | 250.8 | 22555.7 |
| **1995** | 11500.0 | 25596.1 | 5183.5 | 235.9 | 18069.3 |
| **1996** | 14500.0 | 24597.5 | 5187.4 | 207.3 | 21096.6 |
| **1997** | 19400.0 | 22818.1 | 4908.9 | 176.2 | 21915.9 |
| **1998** | 19600.0 | 21109.5 | 4399.0 | 156.2 | 20411.1 |
| **1999** | 19000.0 | 18751.4 | 3608.5 | 136.3 | 17247.4 |
| **2000** | 23000.0 | 19047.2 | 3563.2 | 144.4 | 17812.2 |
| **2001** | 31600.0 | 21811.1 | 3718.8 | 144.1 | 18485.6 |
| **2002** | 27600.0 | 21316.0 | 3514.5 | 142.7 | 19238.8 |
| **2003** | 37500.0 | 20127.6 | 3636.8 | 137.8 | 18613.5 |
| **2004** | 35200.0 | 19600.1 | 3583.3 | 137.4 | 19999.9 |
| **2005** | 40900.0 | 19675.0 | 3919.0 | 207.2 | 23492.1 |
| **2006** | 42700.0 | 20115.9 | 3844.2 | 234.1 | 21517.9 |
| **2007** | 46100.0 | 20494.9 | 4184.9 | 269.2 | 25881.5 |
| **2008** | 47500.0 | 19488.3 | 4150.5 | 318.0 | 27759.5 |
| **2009** | 51900.0 | 18941.0 | 4271.3 | 347.9 | 27966.1 |
| **2010** | 59500.0 | 18945.2 | 4417.4 | 360.3 | 25107.4 |
| **2011** | 59800.0 | 18481.7 | 4500.3 | 383.5 | 25494.0 |
| **2012** | 65200.0 | 18108.1 | 4807.3 | 388.5 | 34674.3 |

| Year | $F_{SN}$ | $F_{OM}$ | $F_{PRP, CPP}$ | $F_{PRP, SO}$ | $F_{CR}$ |
|---|---|---|---|---|---|
| **2013** | 69700.0 | 17951.2 | 5241.9 | 409.5 | 32828.0 |
| **2014** | 72900.0 | 17883.0 | 5613.1 | 441.7 | 35405.2 |
| **2014 versus 2013** | +4.6% | -0.4% | +7.1% | +7.9% | +7.9% |
| **2014 versus 1990** | -44.5% | -65.1% | -64.2% | +19.5% | -13.7% |

*$F_{SN}$ = annual amount of synthetic fertiliser N applied to soils, t N $yr^{-1}$*
*$F_{OM}$ = annual amount of animal manure N applied to soils, t N $yr^{-1}$*
*$F_{PRP\ CPP}$ = annual amount of urine and dung N deposited by grazing cattle, swine and poultry on pasture, t N $yr^{-1}$*
*$F_{PRP\ SO}$ = annual amount of urine and dung N deposited by grazing other animals on pasture, t N $yr^{-1}$*
*$F_{CR}$ = annual amount of N in crop residues (above and below ground), including N-fixing crops, t N $yr^{-1}$*

### 5.4.3 Uncertainties and time-series consistency

The uncertainty of activity data is set to 2%. The uncertainty of the default emission factors reaches +50%.

### 5.4.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the agriculture sector in order to achieve quality objectives. Quality meetings are held annually between experts. A complete coverage of the direct and indirect nitrous oxide emissions from managed land requires estimation of emissions for all anthropogenic inputs and activities ($F_{SN}$, $F_{ON}$, $F_{CR}$, $F_{PRP}$, $F_{SOM}$ and $F_{OS}$), that is done in the inventory. N excretion data are consistent with those used for the manure management systems source category. National crop production and synthetic fertilizer consumption statistics is compared to FAO. CSB of Latvia shows efforts to reduce differences between national statistics and FAO data. All calculations mostly are done according to Tier 1. Fluctuations in time series should be explained by fluctuations of statistical data, showing that agricultural production numbers in Latvia are highly variable. As production levels are strongly associated with support of famers from state, situation on agriculture products market, agricultural products price changes, local demand of agricultural products and other.

### 5.4.5 Category-specific recalculations

Recalculations are done due to the implementation of new emission coefficient for nitrous oxide emission estimation from organic soils and including updated information about organic soil areas (2009-2014) in the inventory. Dry matter fraction values and grassland area was updated for emission calculations from crop residue, based on the revision of current estimation and suggested technical corrections. Recalculations also are affected by implementation of new methodology to determine the share of grazing animals.

### 5.4.6 Category-specific planned improvements

Future development of the country specific value for $Frac_{LEACH}$-(H) and $FRAC_{GASM}$ is planned to estimate N losses by leaching/runoff and volatilization.

## *5.5 FIELD BURNING OF AGRICULTURAL RESIDUES (CRF 3.F)*

Notation key – NO is used for reporting field burning of agricultural residues in Latvia. Legislative measures and agricultural residue management practices prohibit field burning of agricultural residues. This is explained by Latvian Administrative Violations Code Section 179 Violation of Fire Safety Regulations.

## *5.6 LIMING (CRF 3.G)*

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g., calcic limestone ($CaCO_3$), or dolomite (CA $Mg(CO_3)_2$) leads to $CO_2$ emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3^-$), which evolves into $CO_2$ and water ($H_2O$). $CO_2$ emission from additions of carbonate limes to soils are estimated using Tier 1 methodology with the formula from 2006 IPCC Guidelines[176]:

$$CO_2 - C\ Emission = (M_{Limestone} \cdot EF_{Limestone}) + (M_{Dolomite} \cdot EF_{Dolomite})$$

*where:*
*$CO_2$–C Emission = annual C emissions from lime application, tonnes C $yr^{-1}$*
*M = annual amount of calcic limestone ($CaCO_3$) or dolomite (CA $Mg(CO_3)_2$), tonnes $yr^{-1}$*
*EF = emission factor, tonne of C (tonne of limestone or dolomite) $^{-1}$*

IPCC default emission factors are EF=0.12 for limestone and EF=0.13 for dolomite. The uncertainty of them is 50%. Statistical data in Latvia provides information on overall consumption of liming material. Therefore EF 0.13 is implemented for determination of $CO_2$ emissions from liming. Activity data and calculated emissions are represented in Table 5.36.

**Table 5.36 Consumed lime and calculated $CO_2$ emissions, 1990-2014**

| Year | Annual amount of consumed liming material (t $year^{-1}$) | $CO_2$ emissions (kt) |
|---|---|---|
| **1990** | 779200 | 371.42 |
| **1991** | 486700 | 231.99 |
| **1992** | 70600 | 33.65 |
| **1993** | 3500 | 1.67 |
| **1994** | 1600 | 0.76 |
| **1995** | 2700 | 1.29 |
| **1996** | 1400 | 0.67 |
| **1997** | 400 | 0.19 |
| **1998** | 4700 | 2.24 |
| **1999** | 4900 | 2.34 |
| **2000** | 10200 | 4.86 |
| **2001** | 700 | 0.33 |
| **2002** | 32900 | 15.68 |
| **2003** | 53800 | 25.64 |
| **2004** | 2200 | 1.05 |
| **2005** | 3300 | 1.57 |
| **2006** | 3000 | 1.43 |
| **2007** | 10700 | 5.10 |
| **2008** | 6000 | 2.86 |
| **2009** | 8700 | 4.15 |
| **2010** | 4300 | 2.05 |

*[176] 2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.12, page 11.27*

| Year | Annual amount of consumed liming material (t year$^{-1}$) | $CO_2$ emissions (kt) |
|---|---|---|
| **2011** | 17400 | 8.29 |
| **2012** | 21600 | 10.30 |
| **2013** | 28900 | 13.78 |
| **2014** | 41300 | 19.69 |
| **2014 versus 2013** | +42.9% | +42.9% |
| **2014 versus 1990** | -94.7% | -94.7% |

Latvian agricultural land has a tendency to acidification of soil**.** According to information provided by State Plant Protection Service, 53.5% of agricultural land required for liming to neutralize the acidity in 2014. Since 1992, soil liming has to be characterized as insufficient. However, liming activities rapidly increase in the last 5 years.

## *5.7 UREA APPLICATION (CRF 3.H)*

$CO_2$ emission from urea fertilisation is estimated with the following equation from 2006 IPCC Guidelines[177]:

$$CO_2 - C\ Emission = M \cdot EF$$

*where:*
*$CO_2$–C Emission = annual C emissions from urea application, tonnes C yr$^{-1}$*
*M = annual amount of urea fertilisation, tonnes urea yr$^{-1}$*
*EF = emission factor, tonne of C (tonnes of urea)$^{-1}$*

Emission factor (EF) of 0.20 for urea application emissions is used for calculations. The default 50% of uncertainty is applied, activity data uncertainty is evaluated as 2%. CSB of Latvia data of urea application is available from 2007. FAO data for 2002 and 2003 is also available. Data for all other years are derived by extrapolation of available statistical values. Table 5.37 represents activity data and estimated $CO_2$ emissions from urea fertilisation.

**Table 5.37 Urea oundwoodion statistics and calculated $CO_2$ emissions, 1990-2014**

| Year | Annual amount of urea fertilization (tonnes yr$^{-1}$) | $CO_2$ emissions (kt) |
|---|---|---|
| 1990 | 10512 | 7.71 |
| 1991 | 8992 | 6.59 |
| 1992 | 5280 | 3.87 |
| 1993 | 3176 | 2.33 |
| 1994 | 2320 | 1.70 |
| 1995 | 920 | 0.67 |
| 1996 | 1160 | 0.85 |
| 1997 | 1552 | 1.14 |
| 1998 | 1568 | 1.15 |
| 1999 | 1520 | 1.11 |
| 2000 | 1840 | 1.35 |
| 2001 | 2528 | 1.85 |
| 2002 | 6078 | 4.46 |
| 2003 | 1942 | 1.42 |
| 2004 | 1943 | 1.42 |
| 2005 | 1944 | 1.43 |
| 2006 | 1945 | 1.43 |

[177] *2006 IPCC Guidelines. Volume 4, Chapter 11, Equation 11.13, page 11.32*

| Year | Annual amount of urea fertilization (tonnes $yr^{-1}$) | $CO_2$ emissions (kt) |
|---|---|---|
| 2007 | 1946 | 1.43 |
| 2008 | 4323 | 3.17 |
| 2009 | 5930 | 4.35 |
| 2010 | 5459 | 4.00 |
| 2011 | 5798 | 4.25 |
| 2012 | 7901 | 5.79 |
| 2013 | 5558 | 4.08 |
| 2014 | 6445 | 4.73 |
| **2014 versus 2013** | +16.0% | +16.0% |
| **2014 versus 1990** | -38.7% | -38.7% |

## *5.8 OTHER CARBON-CONTAINING FERTILIZERS (CRF 3.I)*

There is no data on other carbon-containing fertilizers use in Latvia. Notation key – NO is used.

## *5.9 OTHER (CRF 3J)*

There is no information on other sources in Latvia. Notation key – NO is used.

# 6 LAND-USE, LAND-USE CHANGE AND FORESTRY (CRF 4)

## *6.1 OVERVIEW OF SECTOR*

Total emissions of aggregated GHG ($CO_2$, $CH_4$ and $N_2O$) in Land Use, Land Use Change and Forestry (LULUCF) sector in 2014 were 4220.14 kt $CO_2$ equivalent (Figure 6.1, Table 6.1, Table 6.2). Aggregated net removals of the GHG reduced by 150 % in 2014 compared to 1990.

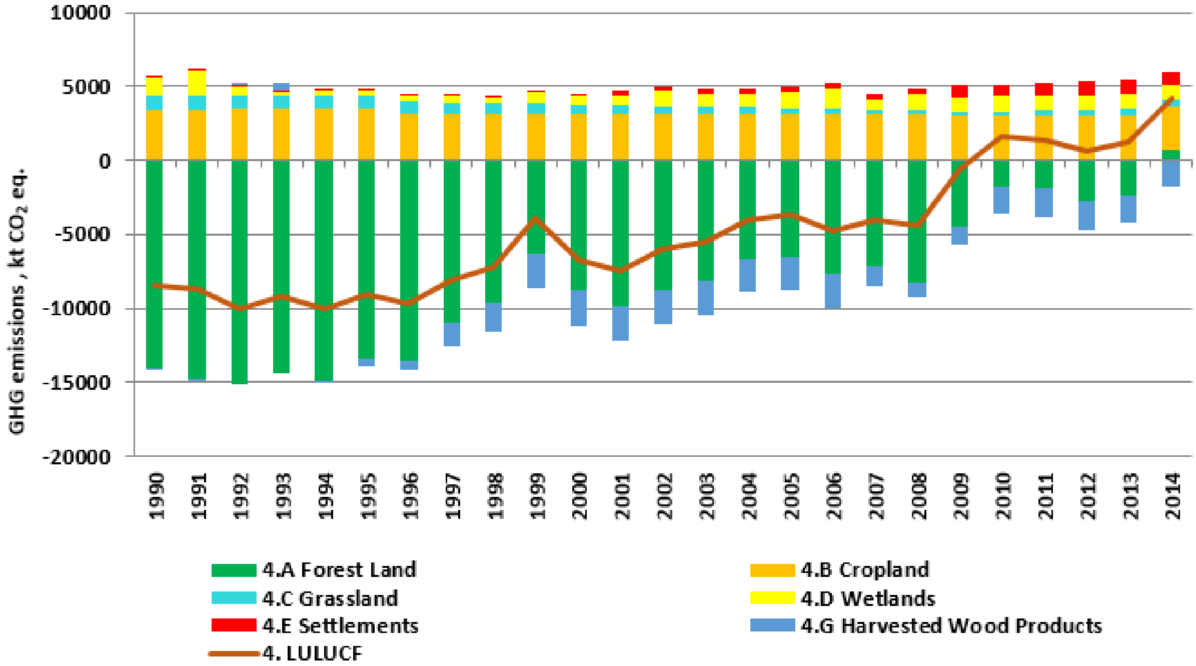


**Figure 6.1 Summary of net emissions (positive sign) and removals (negative sign) in the LULUCF sector by land-use category and harvested wood products (kt $CO_2$ eq.)**

According to the 2006 IPCC Guidelines land area is divided into six land-use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land). In Latvia, LULUCF sector comprises emissions and removals arising from Forest Land, Cropland, Grassland, Wetlands and Settlements divided into the subcategories "lands remaining in the same land-use category for the last 20 years" and "lands converted to present land use during the past 20 years". Other land is considered as unmanaged land and does not contain considerable amount of organic carbon and the emissions and removals are not reported. Emissions and removals from harvested wood products (HWP) are included in the LULUCF estimates.

Summary of net emissions and removals in the LULUCF sector by land-use category and harvested wood products is shown in Table 6.1. Decrease of $CO_2$ removals in living biomass in forest land and cropland is associated with increase of the harvesting rate, increase of mortality and reduction of increment as well as implementation of floating NFI cycle included in the calculations in 2014.

**Table 6.1 Summary of net emissions and removals in the LULUCF sector by land-use category and harvested wood products (positive figures indicate emissions, negative removals) (kt $CO_2$ eq.)**

| Category | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4. LULUCF** | **-8421.63** | **-9037.92** | **-6695.77** | **-3728.88** | **-4716.73** | **-4051.43** | **-4429.32** | **-640.40** | **1574.79** | **1365.10** | **659.16** | **1208.75** | **4220.14** |
| **4.A Forest Land** | **-14006.83** | **-13497.13** | **-8816.64** | **-6531.41** | **-7693.70** | **-7176.14** | **-8222.21** | **-4484.39** | **-1773.97** | **-1854.24** | **-2783.46** | **-2392.13** | **745.83** |
| living biomass | -19117.40 | -17072.79 | -10849.36 | -8319.10 | -10855.17 | -10235.38 | -12224.82 | -7812.51 | -4095.37 | -4633.81 | -6070.17 | -4031.74 | -870.27 |
| dead wood | 75.70 | -1554.22 | -3368.18 | -3074.65 | -1722.62 | -1779.24 | -819.79 | -1645.05 | -2740.66 | -2410.63 | -2038.20 | -3816.75 | -3876.24 |
| litter | -1.38 | -15.78 | -36.01 | -56.07 | -58.85 | -61.58 | -64.95 | -66.10 | -67.25 | -68.40 | -69.55 | -70.70 | -71.84 |
| organic soils | 4749.10 | 4747.47 | 4772.36 | 4775.73 | 4777.39 | 4775.02 | 4777.04 | 4907.85 | 5038.67 | 5169.48 | 5300.30 | 5431.12 | 5455.25 |
| biomass burning | 287.16 | 398.19 | 664.53 | 142.69 | 165.55 | 125.04 | 110.31 | 131.41 | 90.64 | 89.11 | 94.16 | 95.94 | 108.93 |
| **4.B Cropland** | **3419.36** | **3535.54** | **3196.05** | **3150.32** | **3145.60** | **3137.98** | **3133.06** | **3030.88** | **3030.20** | **3027.46** | **3026.68** | **3025.11** | **2890.39** |
| living biomass | 367.23 | 429.56 | 191.89 | 179.06 | 180.98 | 180.97 | 183.73 | 105.59 | 106.08 | 104.83 | 105.54 | 106.44 | 12.89 |
| dead organic matter | 145.69 | 152.04 | 70.11 | 68.59 | 69.70 | 70.25 | 71.14 | 42.04 | 42.93 | 43.75 | 44.56 | 44.64 | 7.40 |
| mineral soils | 6.94 | 41.61 | 55.91 | 68.35 | 70.84 | 73.33 | 75.82 | 78.36 | 73.97 | 69.62 | 65.27 | 60.97 | 54.06 |
| organic soils | 2898.92 | 2908.78 | 2873.38 | 2828.50 | 2818.05 | 2807.19 | 2795.92 | 2798.22 | 2800.92 | 2803.33 | 2805.75 | 2807.87 | 2811.15 |
| 4(III) N mineralization | 0.59 | 3.54 | 4.76 | 5.82 | 6.03 | 6.24 | 6.46 | 6.67 | 6.30 | 5.93 | 5.56 | 5.19 | 4.88 |
| **4.C Grassland** | **971.46** | **812.71** | **614.31** | **406.34** | **371.66** | **291.94** | **248.70** | **274.83** | **299.99** | **353.73** | **407.91** | **460.60** | **486.87** |
| living biomass | -19.18 | -20.69 | -22.19 | -21.74 | -21.74 | -50.31 | -50.31 | -49.50 | -49.50 | -49.50 | -44.06 | -41.72 | -42.88 |
| dead organic matter | -4.28 | -3.62 | -2.78 | -1.78 | -1.48 | -8.65 | -7.96 | -8.15 | -7.64 | -7.12 | -5.08 | -8.71 | -8.56 |
| mineral soils | 0.00 | -139.67 | -301.88 | -481.31 | -521.06 | -561.89 | -603.80 | -603.80 | -603.80 | -575.52 | -554.10 | -525.47 | -495.26 |
| organic soils | 994.82 | 976.60 | 940.74 | 910.80 | 911.13 | 912.03 | 910.55 | 935.45 | 960.46 | 985.58 | 1010.81 | 1036.15 | 1032.29 |
| biomass burning | 0.10 | 0.10 | 0.42 | 0.38 | 4.82 | 0.76 | 0.22 | 0.83 | 0.47 | 0.30 | 0.35 | 0.35 | 1.27 |
| **4.D Wetlands** | **1247.34** | **427.19** | **584.93** | **1120.34** | **1365.20** | **722.18** | **1106.28** | **981.13** | **1021.62** | **1023.40** | **991.10** | **1035.55** | **1014.57** |
| living biomass | -65.31 | -91.56 | -99.60 | -97.94 | -97.98 | -184.50 | -184.50 | -181.69 | -181.69 | -181.69 | -170.06 | -161.43 | -165.23 |
| dead organic matter | -13.81 | -15.69 | -12.34 | -8.12 | -6.86 | -26.89 | -24.50 | -25.18 | -23.35 | -21.62 | -16.88 | -29.96 | -29.47 |
| organic soils | 1326.46 | 534.45 | 696.88 | 1226.41 | 1470.05 | 933.57 | 1315.27 | 1187.99 | 1226.66 | 1226.71 | 1178.04 | 1226.94 | 1209.27 |
| **4.E Settlements** | **113.24** | **156.79** | **157.4** | **372.07** | **385.59** | **335.50** | **350.19** | **781.14** | **822.27** | **854.48** | **905.25** | **940.73** | **897.08** |
| living biomass | 67.62 | 78.44 | 57.50 | 177.83 | 180.31 | 127.14 | 130.69 | 418.43 | 420.73 | 414.88 | 426.67 | 429.85 | 372.73 |
| dead organic matter | 39.54 | 41.90 | 38.20 | 86.17 | 87.95 | 81.75 | 83.62 | 191.23 | 195.70 | 199.86 | 205.15 | 204.00 | 186.88 |
| mineral soils | 1.40 | 8.40 | 13.90 | 24.32 | 26.40 | 28.49 | 30.57 | 45.20 | 58.46 | 71.79 | 85.14 | 98.52 | 107.29 |
| organic soils | 3.77 | 22.59 | 38.53 | 67.49 | 73.29 | 79.08 | 84.87 | 102.43 | 119.84 | 136.64 | 153.16 | 169.38 | 185.61 |
| 4(III) N mineralization | 0.91 | 5.46 | 9.28 | 16.25 | 17.65 | 19.04 | 20.44 | 23.84 | 27.53 | 31.30 | 35.14 | 38.98 | 44.56 |
| **4.G Harvested Wood Products** | **-166.36** | **-473.98** | **-2433.15** | **-2248.32** | **-2292.96** | **-1364.85** | **-1047.38** | **-1226.35** | **-1827.85** | **-2042.44** | **-1891.20** | **-1864.16** | **-1817.58** |

**Table 6.2 Summary of net emissions and removals in the LULUCF sector by different gases (positive figures indicate emissions, negative removals)**

| Emissions, unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total emissions, kt $CO_2$ eq.** | -8421.63 | -9037.92 | -6695.77 | -3728.88 | -4716.73 | -4051.43 | -4429.32 | -640.40 | 1574.79 | 1365.10 | 659.16 | 1208.75 | 4220.14 |
| **$CO_2$, kt** | -9305.34 | -9941.32 | -7639.92 | -4610.85 | -5650.38 | -4936.29 | -5314.74 | -1567.49 | 621.75 | 380.13 | -360.99 | 151.51 | 3133.48 |
| **$CH_4$, kt** | 12,30 | 12.70 | 13.84 | 11.27 | 12.98 | 11.25 | 11.21 | 12.14 | 12.54 | 13.15 | 13.87 | 14.67 | 15.56 |
| **$N_2O$, kt** | 1,93 | 1.97 | 2.01 | 2.01 | 2.04 | 2.03 | 2.03 | 2.09 | 2.15 | 2.20 | 2.26 | 2.32 | 2.34 |
| **$NO_x$, kt** | 0.20 | 0.30 | 0.54 | 0.11 | 0.55 | 0.13 | 0.11 | 0.17 | 0.10 | 0.08 | 0.08 | 0.09 | 0.17 |
| **CO, kt** | 14.24 | 20.84 | 37.77 | 7.40 | 30.82 | 7.77 | 7.42 | 10.54 | 6.41 | 4.99 | 5.04 | 5.96 | 9.87 |

The definitions of carbon pools are as follows:

- Living biomass consist of above-ground biomass (all biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds, and foliage and below-ground biomass (all biomass of live roots and stump, fine roots of less than 2 mm diameter are excluded because these often cannot be distinguished empirically from soil organic matter or litter). Forest understory is a relatively small component of the above-ground biomass carbon pool and it is excluded from calculation in the inventory time series.
- Dead wood consists of all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots down to a diameter of 2 mm, and stumps. Litter includes all non-living biomass with a size greater than the limit for soil organic matter (2 mm) and less than the minimum diameter chosen for dead wood (bottom diameter above 6 cm), lying dead, in various states of decomposition above or within the mineral or organic soil. This includes the litter layer as usually defined in soil typologies. Live fine roots above the mineral or organic soil (wit diameter less than 2 mm) are included in litter where they cannot be distinguished from it empirically.
- Soil carbon is organic carbon in mineral and organic soils (including peat) to a 30 cm depth. Live fine roots of less than 2 mm are included with soil organic matter.

The LULUCF sector is important in Latvia's GHG balance due to the fact that more than half of the country area is covered with forests and due to long history of sustainable forest management which secured continuous increase of growing stock in forests since beginning of 20th century (from 101 $m^3$ $ha^{-1}$ in 1935 to 172 $m^3$ $ha^{-1}$ in 2010)[178]. According to data provided by National statistical forest inventory (NFI) total forest area (including afforested lands) in 2014 was 3 299.38 kha (51 % of total country area). Total area of land converted to forest from 1990 to 2014 is 202.06 kha. Twenty years transition period is considered for land use changes, therefore area of historical forest lands is increasing during recent years, but area of lands converted to forest is decreasing, because area converted to forest until 1993 (including) is now accounted as forest land remaining forest. The same approach is applied to conversion of cropland to grassland. Conversion of forest land to other land use categories in 2014 is calculated using the extrapolation method, assuming that conversion of forest land to cropland and to settlements, as well as conversion of other land use categories follows to a linear regression based on data from 1990 to 2009.

Overview of calculation methods and types of emission factors for the LULUCF sector is shown in Table 6.3. In the forest land category removals and emissions associated with living biomass and soil were estimated using mixed approach of Tier 1 and Tier 2 and country specific activity data, like increment and harvesting figures, mortality rate in forests, wood density values, biomass expansion factors (BEFs), carbon stock in biomass, as well as the land use information. Calculations were done by Latvian State Forest Research Institute "Silava" (LSFRI Silava) with support of Ministry of Agriculture of Republic of Latvia (MoA).

Emissions from organic soils (cropland, grassland, forest land), controlled burning (forest land) and wildfires (forest land and grassland) were estimated using Tier 1 and Tier 2 methods and country specific activity data.

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[178] *https://www.zm.gov.lv/public/ck/files/ZM/mezhi/buklets/MN_20_EN.pdf*

Estimation of conversion of land use from cropland to grassland was introduced in 2011 to represent land use changes associated with reduction of area of cropland. Carbon stock changes are accounted using research data demonstrating difference of carbon stock in cropland and grassland[179].

**Table 6.3 Overview of methods and emission factors used in calculations of GHG emissions from the LULUCF sector**

| CRF | Source | $CO_2$ | | $CH_4$ | | $N_2O$ | |
|---|---|---|---|---|---|---|---|
| | | Methods | EF | Methods | EF | Methods | EF |
| **4.A** | **Forest land** | | | | | | |
| 4.A.1 | Forest Land Remaining Forest Land | Tier 1, Tier 2 | CS, D | Tier 1, Tier 2 | D | Tier 1, Tier 2 | D |
| 4.A.2 | Land Converted to Forest Land | Tier 2 | CS | - | - | - | - |
| 4(II) | Emissions and removals from drainage and rewetting and other management of organic and mineral soils | Tier 1 | D | Tier 1 | D | Tier 1 | D |
| **4.B** | **Cropland** | | | | | | |
| 4.B.1 | Cropland Remaining Cropland | Tier 1, Tier 2 | CS, D | - | - | - | - |
| 4.B.2 | Land Converted to Cropland | Tier 2 | CS | - | - | Tier 1 | D |
| 4(II) | Emissions and removals from drainage and rewetting and other management of organic and mineral soils | - | - | Tier 1 | D | - | - |
| **4.C** | **Grassland** | | | | | | |
| 4.C.1 | Grassland Remaining Grassland | Tier 2 | CS | Tier 1 | D | Tier 1 | D |
| 4.C.2 | Land Converted to Grassland | Tier 1, Tier 2 | CS, D | - | - | - | - |
| 4(II) | Emissions and removals from drainage and rewetting and other management of organic and mineral soils | - | - | Tier 1 | D | - | - |
| **4.D** | **Wetland** | | | | | | |
| 4.D.1 | Wetlands Remaining Wetlands | Tier 1, Tier 2 | CS, D | - | - | - | - |
| 4.D.2 | 4.D.2 Land Converted to Wetlands | - | - | - | - | - | - |
| 4(II) | Emissions and removals from drainage and rewetting and other management of organic and mineral soils | Tier 2 | CS | Tier 1 | D | Tier 1 | D |
| **4.E** | **Settlements** | | | | | | |
| 4.E.1 | Settlements Remaining Settlements | Tier 2 | CS | - | - | Tier 1 | D |
| 4.E.2 | Land Converted to Settlements | Tier 2 | CS | - | - | Tier 1 | D |
| **4.G** | **Harvested Wood Products** | Tier 2 | CS | - | - | - | - |

Emissions of GHG due to forest fires in LULUCF sector are calculated using data about areas of forest fires provided by the State forest service (SFS).

This is the third year when Latvia reported HWP pool using data which were obtained during elaboration of the Forest management reference level (FMRL).

Emissions from drained organic and mineral soils are calculated using default emission factors and national activity data. Information about area of drained mineral and organic soils in forest land is taken from the NFI (total area of forest types on drained soils).

Knowledge about dynamics of dead wood in forest lands is insufficient, both in terms of mortality factors and decay periods, because forest management principles were

[179] *Lazdiņš, Atbalsts Klimata Pētījumu Programmai, starpziņojums Par 2012. Gada Darba Uzdevumu Izpildi (Climate research program, middle-term report, 2012).*

significantly changed since 1990, for instance, in the 80$^{ths}$ it was a common practice to debark stumps and to incinerate harvesting residues to reduce risk of distribution of pests. Nowadays this practice is not used any more in state forests and in very limited amount – in private forests. Instead of that collection of residues for biofuel production becomes more common. Comparison of different sources of information about dead wood (NFI and reports to the Timber Committee) demonstrates constant increase of dead wood stock in forests during the last decade; however, it could be result of several extreme weather events. Mortality factors excluding extreme events were elaborated in 2012 on the base of the NFI data (sample plots measured in 2006 and 2012) for the FMRL calculations[180].

Estimates of emissions from drained forest soils are supplemented with calculation of $N_2O$ emissions from organic soils. Emissions of $CO_2$ from drained organic soils are calculated using default emission factors of the IPCC Wetlands Supplement (2.6 tonnes C $ha^{-1}$ annually in forest land, 7.9 tonnes C $ha^{-1}$ in cropland, 6.1 tonnes C $ha^{-1}$ in grassland and 2.8 tonnes C $ha^{-1}$ in peatlands).

The key categories in LULUCF sector in 2014 in Latvia are summarised in Table 6.4. The most significant key category according to the level assessment (Approach 1) and trend assessment (Approach 1) is Forest land remaining forest land. HWP included into the inventory in 2013 are also a key category by level of net emissions.

**Table 6.4 LULUCF key categories**

| Key categories of emissions and removals | GHG | Identification criteria |
|---|---|---|
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood | $CO_2$ | L1, L2, T1,T2 |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass | $CO_2$ | L1,T1,T2 |
| 4.A.1 Forest land remaining forest land – Controlled burning | $CO_2$ | L1, L2,T1,T2 |
| 4.A.1 Forest Land remaining Forest Land – Drained organic soil | $CO_2$ | L1, L2,T1,T2 |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CO_2$ | L2 |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $N_2O$ | L1,L2,T1,T2 |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | L1, L2,T1,T2 |
| 4.A.2 Land converted to Forest Land – Carbon stock change, grassland converted to forest land | $CO_2$ | L1, L2,T1,T2 |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, dead wood | $CO_2$ | L1 |
| 4.B. Cropland remaining cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | L1, L2 |
| 4.B.1 Cropland remaining Cropland – Drained organic soil | $CO_2$ | L1, L2,T1,T2 |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – living biomass | $CO_2$ | L2 |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | T1,T2 |

[180] *Lazdiņš, Donis, and Strūve, Latvijas Meža Apsaimniekošanas Radītās Oglskābās Gāzes ($CO_2$) Piesaistes Un Siltumnīcefekta Gāzu (SEG) Emisiju References Līmeņa Aprēķina Modeļa Izstrāde (Elaboration of model for estimation of GHG emissions and $CO_2$ removals due to forest management).*

| Key categories of emissions and removals | GHG | Identification criteria |
|---|---|---|
| 4.B.2 Land converted to Cropland – Drained organic soil | $CO_2$ | L1, L2,T2 |
| 4.B.2 Land converted to Cropland – Carbon stock change, forest land converted to cropland | $CO_2$ | T1,T2 |
| 4.B.2 Land converted to Cropland –Mineral soil | $CO_2$ | T2 |
| 4.C.1 Grassland remaining Grassland – Drained organic soil | $CO_2$ | L1, L2,T1,T2 |
| 4.C.2 Land converted to Grassland – Drained organic soil | $CO_2$ | L1, L2,T1,T2 |
| 4.C.2 Land converted to Grassland –Mineral soil | $CO_2$ | L1, L2,T1,T2 |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – living biomass | $CO_2$ | L1, L2,T1,T2 |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change –organic soils | $CO_2$ | L1, L2 |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CO_2$ | L1, L2 |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – living biomass | $CO_2$ | L1, L2,T2 |
| 4.E.2 Land converted to Settlements – Carbon stock change – dead organic matter | $CO_2$ | L1,T1 |
| 4.E.2 Land converted to Settlements – Carbon stock change – living biomass | $CO_2$ | L1, L2,T1,T2 |
| 4.E.2 Land converted to Settlements – Mineral soils | $CO_2$ | L1, L2,T1,T2 |
| 4.E.2 Land converted to Settlements – Organic soils | $CO_2$ | L1, L2,T1,T2 |
| 4. G. Harvested wood products | $CO_2$ | L1, L2, T1,T2 |

The sector reporting was considerably updated during previous inventory due to development of national GHG accounting and projection tool for LULUCF sector and implementation of results of several scientific studies. The most important improvements in this report are implementation of country specific wood density values, carbon stock in different fractions of biomass, BEFs, as well as recalculation of losses due to commercial harvesting and natural mortality in forests.

## *6.2 LAND-USE DEFINITIONS AND THE CLASSIFICATION SYSTEMS USED AND THEIR CORRESPONDENCE TO THE LULUCF CATEGORIES*

For the GHG inventory, land area and inland water bodies are classified according to the 2006 IPCC Guidelines. Connection between the IPCC land-use categories and national land classification is shown in Table 6.5.

**Table 6.5 National application of IPCC land-use categories**

| IPCC category | National land use categories and definitions fits to IPCC categories |
|---|---|
| **Forest land** | Land of a minimum area of 0.1 ha with potential tree crown cover of more than 20 % and with the potential of trees to reach a minimum height of 5 m at maturity. Young natural stands and all plantations established for the forestry purposes, which have to reach a crown density of 20 % or tree height of 5 m. Areas normally forming part of the forest area, which are temporarily unstocked as a result of human intervention or natural causes, but which are expected to revert to forest. For linear formations, a minimum width of 20 m is applied. |
| **Cropland** | Arable land, including orchards and extensively managed arable lands (ploughed at least once per 20 years). Animal feeding glades (periodically ploughed areas if forest used for wild animal feeding), which according to national land use classification belong to forest land. |
| **Grassland** | Pastures, glades and bush-land which do not fit to forest definition. Vegetated |

| IPCC category | National land use categories and definitions fits to IPCC categories |
|---|---|
| | areas on non-forest lands complying to forest definition where land use type can be easily returned to grassland by cutting grass and small trees without legal requirement of transformation of the land use, but except grassland used in forage production and extensively managed cropland reported under cropland. Non-forest lands with average diameter of trees at the breast height less than 2 cm are reported under grassland's category. |
| **Wetlands** | All inland water bodies (rivers, ponds, lakes), swamps (constantly wet areas where height of trees cannot reach more than 5 m and ground vegetation consists mostly of sphagnum and different sword grasses), flood-lands (usually small areas suffering from exceeding water periodically); alluvial lands (larger glades and bush-lands suffering from exceeding water). |
| **Settlements** | Land under buildings including yards and gardens as well as land necessary to maintain and to access those buildings, land under roads including buffer zones, forest infrastructure including ditches and their management bands, as well as seed orchards, forest nurseries and fire-breaks, drainage systems in cropland and grassland, other infrastructure – buffer zones of industrial networks, quarries etc., but excluding peat extraction sites. |
| **Other land** | Dunes not covered by woody vegetation. |

The information about area of all land use categories since 2009 comes from the NFI. Information about grassland, cropland, wetlands and other lands provided by the State land service (SLS) and Central statistical bureau (CSB) are used for reference – to estimate potential errors in the NFI data as well as to estimate the area of cropland and grassland in 1990. Conversion of cropland to grassland is estimated using remote sensing method comparing vegetation index in the NFI sample plots listed as cropland or grassland[181].

The decision support tree was elaborated in 2013 to simplify identification of land use changes in cropland, grassland and forest land using the NFI data analysis (Table 6.6). The identification of land use changes according to this approach takes 10 years. Considering that there are still some unsolved issues, like interpretation of merged sectors of the NFI plots with different initial land use and distribution of biomass located on converted sites, it is proposed to combine automated evaluation and following manual quality assurance.

**Table 6.6 Decision support table to estimate conversion of grassland, cropland and forest land**

| First NFI 2004-2008 | Second NFI 2009-2013 | Third NFI 2014-2019 | Fifth NFI 2020-2024 |
|---|---|---|---|
| Initial land use – *grassland* | Whole plot or sector is ploughed – *no land use change marked* | Whole plot or sector is ploughed – *ploughed area is marked as cropland since second NFI* | Whole plot or sector is ploughed – *the area remains cropland* |
| | | | No signs of ploughing – *the area remains cropland* |
| | | No signs of ploughing – *the area remains grassland* | Whole plot or sector is ploughed – *the area remains grassland* |
| | | | No signs of ploughing – *the area remains grassland* |
| | No signs of ploughing – *the area remains grassland* | Whole plot or sector is ploughed – *the area remains grassland* | Whole plot or sector is ploughed – *ploughed area is marked as cropland since third NFI* |
| | | | No signs of ploughing – *the* |

[181] *Lazdiņš and Zariņš, Vēsturiskās (1990. Gada) Apsaimniekoto Aramzemju Platības Noteikšana Un Līdz 2009. Gadam Notikušo Aramzemju Platības Izmaiņu Novērtēšana (Estimation of area of managed croplands and change of cropland's area until 2009).*

| First NFI 2004-2008 | Second NFI 2009-2013 | Third NFI 2014-2019 | Fifth NFI 2020-2024 |
|---|---|---|---|
| | | | *area remains grassland* |
| | | No signs of ploughing – *the area remains grassland* | Whole plot or sector is ploughed – *the area remains grassland* |
| | | | No signs of ploughing – *the area remains grassland* |

The areas of IPCC land-use categories and Latvia's official land area are given in Table 6.7. Slight changes are applied to the whole cycle due to harmonization of the country area.

**Table 6.7 Areas of IPCC land-use classes in 1990-2014, 1000 ha[182]**

| Year | Total country area | Forest land | Cropland | Grassland | Settlements | Wetland | Other land |
|---|---|---|---|---|---|---|---|
| **1990** | 6 457.30 | 3 124.22 | 1 842.24 | 798.24 | 238.82 | 448.35 | 5.44 |
| **1991** | 6 457.30 | 3 128.56 | 1 837.27 | 798.26 | 239.41 | 448.35 | 5.44 |
| **1992** | 6 457.30 | 3 135.28 | 1 833.98 | 794.24 | 240.01 | 448.35 | 5.44 |
| **1993** | 6 457.30 | 3 143.49 | 1 828.93 | 790.49 | 240.60 | 448.35 | 5.44 |
| **1994** | 6 457.30 | 3 149.67 | 1 823.50 | 789.15 | 241.19 | 448.35 | 5.44 |
| **1995** | 6 457.30 | 3 160.27 | 1 817.85 | 783.61 | 241.78 | 448.35 | 5.44 |
| **1996** | 6 457.30 | 3 173.39 | 1 810.36 | 777.51 | 242.26 | 448.35 | 5.44 |
| **1997** | 6 457.30 | 3 185.24 | 1 802.95 | 772.60 | 242.73 | 448.35 | 5.44 |
| **1998** | 6 457.30 | 3 197.95 | 1 797.12 | 765.24 | 243.20 | 448.35 | 5.44 |
| **1999** | 6 457.30 | 3 209.19 | 1 789.13 | 761.52 | 243.67 | 448.35 | 5.44 |
| **2000** | 6 457.30 | 3 222.13 | 1 782.39 | 754.84 | 244.15 | 448.35 | 5.44 |
| **2001** | 6 457.30 | 3 236.66 | 1 773.20 | 748.62 | 245.04 | 448.35 | 5.44 |
| **2002** | 6 457.30 | 3 248.73 | 1 766.53 | 742.32 | 245.92 | 448.35 | 5.44 |
| **2003** | 6 457.30 | 3 257.90 | 1 759.41 | 739.39 | 246.81 | 448.35 | 5.44 |
| **2004** | 6 457.30 | 3 270.95 | 1 750.97 | 733.90 | 247.70 | 448.35 | 5.44 |
| **2005** | 6 457.30 | 3 281.85 | 1 742.26 | 730.82 | 248.59 | 448.35 | 5.44 |
| **2006** | 6 457.30 | 3 289.65 | 1 733.30 | 731.09 | 249.48 | 448.35 | 5.44 |
| **2007** | 6 457.30 | 3 297.27 | 1 724.07 | 731.81 | 250.36 | 448.35 | 5.44 |
| **2008** | 6 457.30 | 3 307.06 | 1 714.58 | 730.62 | 251.25 | 448.35 | 5.44 |
| **2009** | 6 457.30 | 3 305.78 | 1 714.80 | 731.72 | 251.66 | 447.90 | 5.44 |
| **2010** | 6 457.30 | 3 304.50 | 1 715.02 | 732.82 | 252.08 | 447.44 | 5.44 |
| **2011** | 6 457.30 | 3 303.22 | 1 715.24 | 733.93 | 252.49 | 446.99 | 5.44 |
| **2012** | 6 457.30 | 3 301.94 | 1 715.45 | 735.03 | 252.90 | 446.54 | 5.44 |
| **2013** | 6 457.30 | 3 300.66 | 1 715.67 | 736.13 | 253.32 | 446.09 | 5.44 |
| **2014** | 6 457.30 | 3 299.38 | 1 715.89 | 737.23 | 253.73 | 445.63 | 5.44 |

Area of organic soils in croplands and grasslands is updated according to the inventory of historical data about farmlands implemented in 2009[183]. Area of cropland and grassland in LULUCF reporting is synchronized with Agriculture reporting, including recalculation of cultivated organic soils. It is considered that all forest land, grassland, cropland and settlements are managed. Detailed land use change matrices are provided in Table 6.9; summary – in Table 6.8.

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[182]*Based on the NFI data.*
[183]*L.U. Consulting, "Augšņu un reljefa izejas datu sagatavošana un Eiropas Komisijas izstrādāto augsnes un reljefa kritēriju mazāk labvēlīgo apvidu noteikšanai piemērošanas simulācija (Projekta kopsavilkuma ziņojums)" (Elaboration of soil and terrain data and simulation of application of the criteria elaborated by the European Commission for identification of less valuable regions (Summary of the project report)), Latvijas Republikas Zemkopības Ministrija, 2010.*

**Table 6.8 Summary of land use change matrix (1000 ha)**

| Changes | To Forest land | To Cropland | To Grassland | To Settlements | To Wetland | To Other land |
|---|---|---|---|---|---|---|
| **1990** | **3124.22** | **1842.24** | **798.24** | **238.82** | **448.35** | **5.44** |
| **From Forest land** | | 21.43 | 7.73 | 23.78 | 9.41 | 0.00 |
| **From Cropland** | 1.75 | | 146.65 | 2.11 | 0.00 | 0.00 |
| **From Grassland** | 214.27 | 0.00 | | 13.82 | 6.13 | 0.00 |
| **From Settlements** | 9.11 | 2.60 | 12.70 | | 1.51 | 0.00 |
| **From Wetland** | 12.38 | 0.13 | 6.14 | 1.12 | | 0.00 |
| **From Other land** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| **2014** | **3299.38** | **1715.89** | **737.23** | **253.73** | **445.63** | **5.44** |

**Table 6.9 Land use change matrix (1000 ha)**

| Changes | To Forest land | To Cropland | To Grassland | To Settlements | To Wetland | To Other land |
|---|---|---|---|---|---|---|
| **Land use change 1989-1990** | | | | | | |
| 1989 | 3 122.06 | 1 840.33 | 802.90 | 238.23 | 448.35 | 5.43 |
| From Forest land | 1 840.33 | 1.91 | | 0.59 | | |
| From Cropland | 802.90 | | 0.00 | | | |
| From Grassland | 238.23 | | | | | |
| From Settlements | 448.35 | | | | | |
| From Wetland | 4.32 | | | | | |
| From Other land | | | | | | |
| **Land use change 1990-1991** | | | | | | |
| 1990 | 3 124.22 | 1 842.24 | 798.24 | 238.82 | 448.35 | 5.44 |
| From Forest land | | 1.91 | | 0.59 | | |
| From Cropland | | | 6.87 | | | |
| From Grassland | 6.85 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 1991-1992** | | | | | | |
| 1991 | 3 128.56 | 1 837.27 | 798.26 | 239.41 | 448.35 | 5.44 |
| From Forest land | | 1.91 | | 0.59 | | |
| From Cropland | | | 5.20 | | | |
| From Grassland | 9.22 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 1992-1993** | | | | | | |
| 1992 | 3 135.28 | 1 833.98 | 794.24 | 240.01 | 448.35 | 5.44 |
| From Forest land | | 1.91 | | 0.59 | | |
| From Cropland | | | 6.95 | | | |
| From Grassland | 10.70 | | | | | |

| Changes | To Forest land | To Cropland | To Grassland | To Settlements | To Wetland | To Other land |
|---|---|---|---|---|---|---|
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 1993-1994** | | | | | | |
| 1993 | 3 143.49 | 1 828.93 | 790.49 | 240.60 | 448.35 | 5.44 |
| From Forest land | | 1.91 | | 0.59 | | |
| From Cropland | | | 7.34 | | | |
| From Grassland | 8.68 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 1994-1995** | | | | | | |
| 1994 | 3 149.67 | 1 823.50 | 789.15 | 241.19 | 448.35 | 5.44 |
| From Forest land | | 1.91 | | 0.59 | | |
| From Cropland | | | 7.56 | | | |
| From Grassland | 13.09 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 1995-1996** | | | | | | |
| 1995 | 3 160.27 | 1 817.85 | 783.61 | 241.78 | 448.35 | 5.44 |
| From Forest land | | 0.79 | | 0.47 | | |
| From Cropland | | | 8.27 | | | |
| From Grassland | 14.38 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 1996-1997** | | | | | | |
| 1996 | 3 173.39 | 1 810.36 | 777.51 | 242.26 | 448.35 | 5.44 |
| From Forest land | | 0.79 | | 0.47 | | |
| From Cropland | | | 8.21 | | | |
| From Grassland | 13.12 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 1997-1998** | | | | | | |
| 1997 | 3 185.24 | 1 802.95 | 772.60 | 242.73 | 448.35 | 5.44 |
| From Forest land | | 0.79 | | 0.47 | | |
| From Cropland | | | 6.61 | | | |
| From Grassland | 13.96 | | | | | |
| From Settlements | | | | | | |

| Changes | To Forest land | To Cropland | To Grassland | To Settlements | To Wetland | To Other land |
|---|---|---|---|---|---|---|
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 1998-1999** | | | | | | |
| 1998 | 3 197.95 | 1 797.12 | 765.24 | 243.20 | 448.35 | 5.44 |
| From Forest land | | 0.79 | | 0.47 | | |
| From Cropland | | | 8.78 | | | |
| From Grassland | 12.50 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 1999-2000** | | | | | | |
| 1999 | 3 209.19 | 1 789.13 | 761.52 | 243.67 | 448.35 | 5.44 |
| From Forest land | | 0.79 | | 0.47 | | |
| From Cropland | | | 7.53 | | | |
| From Grassland | 14.20 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 2000-2001** | | | | | | |
| 2000 | 3 222.13 | 1 782.39 | 754.84 | 244.15 | 448.35 | 5.44 |
| From Forest land | | 0.69 | | 0.89 | | |
| From Cropland | | | 9.89 | | | |
| From Grassland | 16.11 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 2001-2002** | | | | | | |
| 2001 | 3 236.66 | 1 773.20 | 748.62 | 245.04 | 448.35 | 5.44 |
| From Forest land | | 0.69 | | 0.89 | | |
| From Cropland | | | 7.35 | | | |
| From Grassland | 13.66 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 2002-2003** | | | | | | |
| 2002 | 3 248.73 | 1 766.53 | 742.32 | 245.92 | 448.35 | 5.44 |
| From Forest land | | 0.69 | | 0.89 | | |
| From Cropland | | | 7.82 | | | |
| From Grassland | 10.74 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |

| **Changes** | **To Forest land** | **To Cropland** | **To Grassland** | **To Settlements** | **To Wetland** | **To Other land** |
|---|---|---|---|---|---|---|
| **Land use change 2003-2004** | | | | | | |
| 2003 | 3 257.90 | 1 759.41 | 739.39 | 246.81 | 448.35 | 5.44 |
| From Forest land | | 0.69 | | 0.89 | | |
| From Cropland | | | 9.13 | | | |
| From Grassland | 14.62 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 2004-2005** | | | | | | |
| 2004 | 3 270.95 | 1 750.97 | 733.90 | 247.70 | 448.35 | 5.44 |
| From Forest land | | 0.69 | | 0.89 | | |
| From Cropland | | | 9.39 | | | |
| From Grassland | 12.48 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 2005-2006** | | | | | | |
| 2005 | 3 281.85 | 1 742.26 | 730.82 | 248.59 | 448.35 | 5.44 |
| From Forest land | | 0.69 | | 0.89 | | |
| From Cropland | | | 9.65 | | | |
| From Grassland | 9.39 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 2006-2007** | | | | | | |
| 2006 | 3 289.65 | 1 733.30 | 731.09 | 249.48 | 448.35 | 5.44 |
| From Forest land | | 0.69 | | 0.89 | | |
| From Cropland | | | 9.92 | | | |
| From Grassland | 9.19 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 2007-2008** | | | | | | |
| 2007 | 3 297.27 | 1 724.07 | 731.81 | 250.36 | 448.35 | 5.44 |
| From Forest land | | 0.69 | | 0.89 | | |
| From Cropland | | | 10.18 | | | |
| From Grassland | 11.37 | | | | | |
| From Settlements | | | | | | |
| From Wetland | | | | | | |
| From Other land | | | | | | |
| **Land use change 2008-2009** | | | | | | |
| 2008 | 3 307.06 | 1 714.58 | 730.62 | 251.25 | 448.35 | 5.44 |

| Changes | To Forest land | To Cropland | To Grassland | To Settlements | To Wetland | To Other land |
|---|---|---|---|---|---|---|
| From Forest land | | 0.41 | 1.29 | 1.89 | 1.57 | |
| From Cropland | 0.29 | | | 0.35 | | |
| From Grassland | | | | 2.30 | 1.02 | |
| From Settlements | 1.52 | 0.43 | 2.12 | | 0.25 | |
| From Wetland | 2.06 | 0.02 | 1.02 | 0.19 | | |
| From Other land | | | | | | |
| **Land use change 2009-2010** | | | | | | |
| 2009 | 3 305.78 | 1 714.80 | 731.72 | 251.66 | 447.90 | 5.44 |
| From Forest land | | 0.41 | 1.29 | 1.89 | 1.57 | |
| From Cropland | 0.29 | | | 0.35 | | |
| From Grassland | | | | 2.30 | 1.02 | |
| From Settlements | 1.52 | 0.43 | 2.12 | | 0.25 | |
| From Wetland | 2.06 | 0.02 | 1.02 | 0.19 | | |
| From Other land | | | | | | |
| **Land use change 2010-2011** | | | | | | |
| 2010 | 3 304.50 | 1 715.02 | 732.82 | 252.08 | 447.44 | 5.44 |
| From Forest land | | 0.41 | 1.29 | 1.89 | 1.57 | |
| From Cropland | 0.29 | | | 0.35 | | |
| From Grassland | | | | 2.30 | 1.02 | |
| From Settlements | 1.52 | 0.43 | 2.12 | | 0.25 | |
| From Wetland | 2.06 | 0.02 | 1.02 | 0.19 | | |
| From Other land | | | | | | |
| **Land use change 2011-2012** | | | | | | |
| 2011 | 3 303.22 | 1 715.24 | 733.93 | 252.49 | 446.99 | 5.44 |
| From Forest land | | 0.41 | 1.29 | 1.89 | 1.57 | |
| From Cropland | 0.29 | | | 0.35 | | |
| From Grassland | | | | 2.30 | 1.02 | |
| From Settlements | 1.52 | 0.43 | 2.12 | | 0.25 | |
| From Wetland | 2.06 | 0.02 | 1.02 | 0.19 | | |
| From Other land | | | | | | |
| **Land use change 2012-2013** | | | | | | |
| 2012 | 3 301.94 | 1 715.45 | 735.03 | 252.90 | 446.54 | 5.44 |
| From Forest land | | 0.41 | 1.29 | 1.89 | 1.57 | |
| From Cropland | 0.29 | | | 0.35 | | |
| From Grassland | | | | 2.30 | 1.02 | |
| From Settlements | 1.52 | 0.43 | 2.12 | | 0.25 | |
| From Wetland | 2.06 | 0.02 | 1.02 | 0.19 | | |
| From Other land | | | | | | |
| **Land use change 2013-2014** | | | | | | |
| 2013 | 3 300.66 | 1 715.67 | 736.13 | 253.32 | 446.09 | 5.44 |
| From Forest land | | 0.41 | 1.29 | 1.89 | 1.57 | |

| Changes | To Forest land | To Cropland | To Grassland | To Settlements | To Wetland | To Other land |
|---|---|---|---|---|---|---|
| From Cropland | 0.29 | | | 0.35 | | |
| From Grassland | | | | 2.30 | 1.02 | |
| From Settlements | 1.52 | 0.43 | 2.12 | | 0.25 | |
| From Wetland | 2.06 | 0.02 | 1.02 | 0.19 | | |
| From Other land | | | | | | |
| 2014 | 3299.38 | 1715.89 | 737.23 | 253.73 | 445.63 | 5.44 |

## *6.3 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION*

Spatial approach is used to represent area of forest land, grassland, cropland, wetlands, settlements and other lands. Activity data are provided by the National forest inventory (NFI)[184]. Source data of the inventory (about 16000 plots representing 400 ha each) are used in calculations of land use and land use changes, as well as drainage and rewetting of forest land. The NFI data are adapted to the harmonized country area for the whole accounting period and to land use categories used in the GHG inventory. Two cycles of the NFI (2004-2008 and 2009-2013) are used in the GHG inventory.

Research data (LANDSAT images based remote sensing studies) are used to identify forest and woody areas converted to cropland and settlement as well as extensively managed croplands, like biological farms, where considerable area of arable land is set aside for a longer time period and can be reported by the NFI teams as grassland or forest land, depending from structure of vegetation. Vegetation index were estimated in all the NFI points, including those outside forest lands in satellite image series from 1990, 1995 and 2000 to identify points where vegetation index permanently changed from values characteristic for forest lands to the one's characteristic for settlements, grassland and cropland.

Area of cropland considerably increased and area of grasslands decreased, when research data were applied, in comparison to the original NFI data, because extensively managed farmlands (biological farms and grassland utilized in forage production) are accounted under cropland category as well as lands, which at least once per 10 years have value of vegetation index typical for cropland.

Land use categories (except forest land) converted to cropland are estimated since 2009, when the 2$^{nd}$ cycle of the NFI was started in Latvia; however, there are no evidences of conversion of considerable area of land use categories to cropland since 1990 due to the fact that the area of cropland continuously decreased until 2008. Later according to the NFI data it is stabilizing; however, it is complicated to identify, if returning to conventional agricultural practice are occasional cases or it is continuous process. Therefore, there is 5 years delay period (between 2 NFI cycles) to approve land use change from grassland to cropland or opposite, as well as afforestation and conversion of forest land to grassland.

[184] *Source – http://www.silava.lv/userfiles/file/Meza%20statistiska%20inventarizacija/Kopsavilkumi%202014%20I%20cikls%20(2).xlsx; http://www.silava.lv/userfiles/file/Meza%20statistiska%20inventarizacija/Kopsavilkumi%202014%20II%20cikls%20(2).xlsx*

Area of land converted to settlements before 2004 is estimated using LANDSAT satellite images within the scope of the project "Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol article 3.3 and 3.4 activities"[185].

## *6.4 FOREST LAND (CRF 4.A)*

### 6.4.1 Category description

From 1990 to 2013 forest land was a net sink, but in 2014 forest land was a net source because the total emissions resulting from forest land were bigger than the total removals. Total GHG emissions from forest lands, excluding harvested wood products in 2014 were 745.83 kt $CO_2$ eq. (Figure 6.2).

Forest land category includes emissions and removals resulting from carbon stock changes in living biomass, litter, dead wood, organic soils and emissions from drainage and rewetting of organic soils as well as biomass burning. Forest land category is subdivided into Forest land remaining forest land (CRF 4.A.1) and Land converted to forest land more than 20 years ago (CRF 4.A.2). The aggregated net GHG emissions from forest land remaining forest were 370.68 kt of $CO_2$ eq. in Latvia in 2014, excluding removals in harvested wood products (respectively -1817.58 kt $CO_2$) and emissions from drainage and rewetting of organic soils (respectively 810.72 kt $CO_2$ eq.). The net emissions from land converted to forest in 2014 were -435.57 kt $CO_2$ eq. (Figure 6.2).

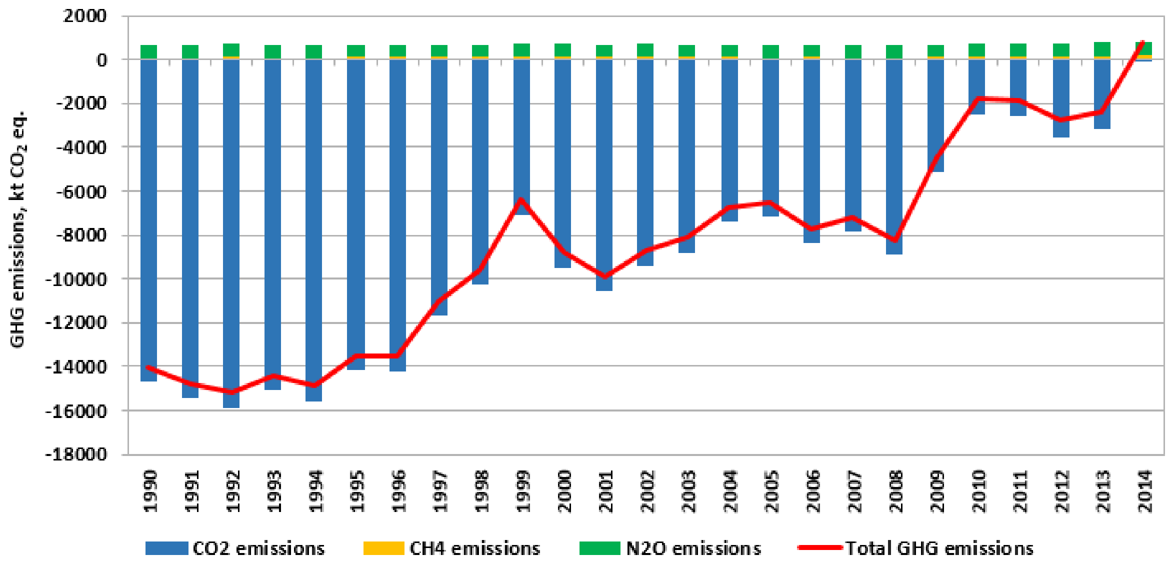


**Figure 6.2 Summary of GHG emissions in forest land (kt $CO_2$ eq.)**

There are several key source and sink categories in forest land in Latvia – $CO_2$ in Forest Land remaining Forest Land and $CO_2$ in Land converted to Forest Land as well as 3 key source categories ($CO_2$, $CH_4$ and $N_2O$) under Emissions and removals from drainage and rewetting

[185] *Lazdiņš and Zariņš, "Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol article 3.3 and 3.4 activities (Report on research work contracted by the Ministry of Environment of republic of Latvia)."*

and other management of organic and mineral soils which are now evaluated separately in the CRF reporter.

The estimation of the area of forest land is based on the NFI[186].

The NFI and research data are used to estimate time series for areas and gross increment. Mortality data are calculated on the base of the NFI data and mortality factors, considering linear correlation between the modelled mortality in 2009-2014 and actual mortality data for the whole period[187]. Distinction between forest land remaining forest land and areas converted to forest land is made according to the age of dominant species in forests on afforested land – if age of dominant species was less than zero in 1990, it is considered as land converted to forest, in other cases it is considered as forest land remaining forest land.

Carbon stock changes in above and below ground living and dead biomass are reported in the submission. Decay factor for dead wood including harvesting residues not incinerated on-site is considered 20 years. Changes of organic carbon in litter and soil organic matter in naturally dry and wet soils are assumed to be zero according to research data on carbon stock in forest soil in 2006 and 2012[188].

Carbon stock changes are reported separately on naturally dry and wet mineral and organic soils and drained mineral and organic soils. Soils are considered organic as defined in the NFI: a soil is classified as organic if the organic layer (H horizon) is at least 20 cm deep. Distribution of the forest site types according to the NFI is shown in Table 6.10. Conversion of forest stands on drained mineral or organic soil to naturally wet soil is accounted as rewetting.

**Table 6.10 Distribution of drained, naturally dry and wet mineral and organic soils in Latvia's forests, 1000 ha**

| Year | Forest at the end of year | Forest on dry mineral soils | Forest on drained mineral soils | Forest on wet mineral soils | Forest on drained organic soils | Forest on wet organic soils |
|---|---|---|---|---|---|---|
| **1990** | 3124.22 | 1544.49 | 611.03 | 262.82 | 432.75 | 273.13 |
| **1991** | 3128.56 | 1547.62 | 612.29 | 262.93 | 432.81 | 272.91 |
| **1992** | 3135.28 | 1553.75 | 612.63 | 263.38 | 432.83 | 272.70 |
| **1993** | 3143.49 | 1560.73 | 613.49 | 263.50 | 432.89 | 272.88 |
| **1994** | 3149.67 | 1564.29 | 616.19 | 263.65 | 432.54 | 273.01 |
| **1995** | 3160.27 | 1573.23 | 618.24 | 263.41 | 432.60 | 272.79 |
| **1996** | 3173.39 | 1583.28 | 619.44 | 265.04 | 433.06 | 272.58 |
| **1997** | 3185.24 | 1592.98 | 619.68 | 265.83 | 433.90 | 272.87 |
| **1998** | 3197.95 | 1602.72 | 620.49 | 266.87 | 434.45 | 273.42 |
| **1999** | 3209.19 | 1612.69 | 622.15 | 266.75 | 434.28 | 273.31 |
| **2000** | 3222.13 | 1623.61 | 622.71 | 267.53 | 434.87 | 273.41 |
| **2001** | 3236.66 | 1636.02 | 625.28 | 267.29 | 434.76 | 273.30 |

[186]*http://www.silava.lv/userfiles/file/2010%20nov%20MRM_visi%20mezi_04-08g.xls*

[187] *Lazdiņš, Donis, and Strūve, Latvijas Meža Apsaimniekošanas Radītās Ogļskābās Gāzes ($CO_2$) Piesaistes Un Siltumnīcefekta Gāzu (SEG) Emisiju References Līmeņa Aprēķina Modeļa Izstrāde (Elaboration of calculation model for evaluation of GHG emissions and $CO_2$ removals due to forest management).*

[188] *Lazdiņš et al., "Temporary Carbon Stock Changes in Forest Soil in Latvia"; Lazdiņš et al., Mežsaimniecisko Darbību Ietekmes Uz Siltumnīcefekta Gāzu Emisijām Un $CO_2$ Piesaisti Novērtējums (pārskats Par 2012. Gada Darba Uzdevumu Izpildi).*

| Year | Forest at the end of year | Forest on dry mineral soils | Forest on drained mineral soils | Forest on wet mineral soils | Forest on drained organic soils | Forest on wet organic soils |
|---|---|---|---|---|---|---|
| **2002** | 3248.73 | 1647.32 | 626.10 | 267.61 | 434.54 | 273.16 |
| **2003** | 3257.90 | 1655.39 | 627.50 | 267.46 | 434.52 | 273.03 |
| **2004** | 3270.95 | 1667.23 | 627.79 | 267.83 | 435.20 | 272.89 |
| **2005** | 3281.85 | 1677.04 | 628.80 | 268.08 | 435.18 | 272.75 |
| **2006** | 3289.65 | 1684.20 | 629.60 | 267.91 | 435.33 | 272.62 |
| **2007** | 3297.27 | 1689.66 | 630.73 | 268.88 | 435.11 | 272.88 |
| **2008** | 3307.06 | 1698.81 | 631.23 | 268.73 | 435.30 | 273.00 |
| **2009** | 3305.78 | 1676.17 | 681.61 | 260.91 | 445.56 | 241.54 |
| **2010** | 3304.50 | 1653.52 | 731.99 | 253.08 | 455.83 | 210.08 |
| **2011** | 3303.22 | 1630.88 | 782.36 | 245.26 | 466.10 | 178.62 |
| **2012** | 3301.94 | 1608.24 | 832.74 | 237.43 | 476.37 | 147.15 |
| **2013** | 3300.66 | 1585.59 | 883.12 | 229.61 | 486.64 | 115.69 |
| **2014** | 3299.38 | 1586.32 | 882.16 | 229.39 | 485.96 | 115.55 |

The carbon stock change in living biomass is estimated with the default method of the 2006 IPCC Guidelines – carbon uptake and release of the living biomass correspond to the mean gross annual increment of forest growing stock, annual harvesting of trees and decay due to natural mortality.

The time series for annual increment of growing stock of trees on a forest land remaining forest are given in Table 6.11 and in the land converted to forest – in Table 6.12.

The dynamics of carbon stock changes in living biomass is very much affected by commercial felling. The demand for timber products was low at the beginning of the 1990s; therefore, felling was also at a low level and the $CO_2$ sink of trees was high. The felling stock increased during 1990s and reached top average in early 2000s. Updated figures[189] of felling, including biofuel gathering, are shown in Table 6.13.

The Land converted to forest land provides relatively small net increment of growing stock of trees – about 0.27 mill. $M^3$ in 2014. Taking into account that these forests are generally young stands, no emissions from commercial felling are considered. Areas afforested 20 years ago (in 1990-1993) are accounted under the forest land remaining forest land category.

**Table 6.11 Annual increment of growing stock of trees on the forest land remaining forest, 1000 $m^3$**

| Year | Aspen | Grey alder | Birch | Spruce | Black alder | Oak, ash | Other | Pine | Total |
|---|---|---|---|---|---|---|---|---|---|
| **1990** | 3684.80 | 2033.55 | 7745.47 | 4015.37 | 1666.90 | 281.19 | 531.56 | 6345.51 | 26304.35 |
| **1991** | 3681.85 | 2031.92 | 7739.27 | 4012.15 | 1665.57 | 280.96 | 531.14 | 6340.43 | 26283.28 |
| **1992** | 3678.90 | 2030.29 | 7733.06 | 4008.93 | 1664.23 | 280.74 | 530.71 | 6335.35 | 26262.21 |
| **1993** | 3675.95 | 2028.66 | 7726.86 | 4005.72 | 1662.89 | 280.51 | 530.28 | 6330.26 | 26241.14 |
| **1994** | 3757.81 | 2187.73 | 7872.38 | 4593.49 | 1826.05 | 288.24 | 470.81 | 6397.34 | 27393.83 |
| **1995** | 3754.79 | 2185.97 | 7866.05 | 4589.80 | 1824.58 | 288.00 | 470.43 | 6392.19 | 27371.81 |
| **1996** | 3753.27 | 2185.08 | 7862.85 | 4587.93 | 1823.84 | 287.89 | 470.24 | 6389.60 | 27360.7 |
| **1997** | 3751.74 | 2184.19 | 7859.66 | 4586.07 | 1823.10 | 287.77 | 470.05 | 6387.00 | 27349.58 |
| **1998** | 3750.22 | 2183.31 | 7856.46 | 4584.20 | 1822.36 | 287.65 | 469.86 | 6384.41 | 27338.46 |

[189] *Values updated according to results of the second NFI cycle.*

| Year | Aspen | Grey alder | Birch | Spruce | Black alder | Oak, ash | Other | Pine | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1999 | 3378.42 | 2251.29 | 7748.63 | 5315.08 | 1865.29 | 275.51 | 455.05 | 6575.32 | 27864.59 |
| 2000 | 3377.04 | 2250.37 | 7745.48 | 5312.92 | 1864.53 | 275.40 | 454.87 | 6572.65 | 27853.26 |
| 2001 | 3375.32 | 2249.22 | 7741.54 | 5310.21 | 1863.58 | 275.26 | 454.63 | 6569.30 | 27839.08 |
| 2002 | 3373.61 | 2248.08 | 7737.60 | 5307.51 | 1862.63 | 275.12 | 454.40 | 6565.96 | 27824.91 |
| 2003 | 3371.89 | 2246.93 | 7733.66 | 5304.81 | 1861.68 | 274.98 | 454.17 | 6562.61 | 27810.73 |
| 2004 | 2333.51 | 2386.37 | 6740.73 | 5176.77 | 1474.25 | 297.33 | 372.51 | 7467.19 | 26248.65 |
| 2005 | 2332.32 | 2385.15 | 6737.30 | 5174.13 | 1473.50 | 297.18 | 372.32 | 7463.38 | 26235.27 |
| 2006 | 2331.13 | 2383.93 | 6733.86 | 5171.49 | 1472.75 | 297.03 | 372.13 | 7459.57 | 26221.88 |
| 2007 | 2329.94 | 2382.72 | 6730.42 | 5168.85 | 1471.99 | 296.88 | 371.94 | 7455.76 | 26208.5 |
| 2008 | 2328.75 | 2381.50 | 6726.99 | 5166.21 | 1471.24 | 296.72 | 371.75 | 7451.95 | 26195.11 |
| 2009 | 2675.44 | 2137.61 | 6420.48 | 5238.86 | 1514.00 | 382.17 | 230.97 | 6268.39 | 24867.92 |
| 2010 | 2675.01 | 2137.26 | 6419.45 | 5238.02 | 1513.76 | 382.11 | 230.93 | 6267.38 | 24863.93 |
| 2011 | 2676.48 | 2138.43 | 6422.97 | 5240.90 | 1514.59 | 382.32 | 231.06 | 6270.82 | 24877.56 |
| 2012 | 2680.01 | 2141.26 | 6431.44 | 5247.81 | 1516.59 | 382.82 | 231.36 | 6279.09 | 24910.38 |
| 2013 | 2684.83 | 2145.10 | 6443.00 | 5257.24 | 1519.31 | 383.51 | 231.78 | 6290.37 | 24955.14 |
| 2014 | 4019.14 | 2394.16 | 4504.76 | 3311.98 | 4099.90 | 1584.68 | 266.02 | 4121.84 | 24302.47 |

**Table 6.12 Increment of growing stock of timber on the Land converted to forest[190]**

| Year | Net increment, $m^3$ | Stem biomass, 1000 tonnes | Crown biomass, 1000 tonnes | Below-ground biomass, 1000 tonnes | Total biomass, 1000 tonnes |
|---|---|---|---|---|---|
| 1990 | 123.46 | 0.05 | 0.02 | 0.02 | 0.08 |
| 1991 | 503.10 | 0.21 | 0.06 | 0.06 | 0.34 |
| 1992 | 1280.42 | 0.53 | 0.16 | 0.17 | 0.85 |
| 1993 | 2586.57 | 1.06 | 0.33 | 0.33 | 1.72 |
| 1994 | 4457.40 | 1.83 | 0.57 | 0.58 | 2.98 |
| 1995 | 7045.30 | 2.89 | 0.90 | 0.91 | 4.71 |
| 1996 | 10494.13 | 4.31 | 1.35 | 1.36 | 7.01 |
| 1997 | 14868.59 | 6.10 | 1.91 | 1.92 | 9.94 |
| 1998 | 20248.26 | 8.31 | 2.60 | 2.62 | 13.53 |
| 1999 | 26663.37 | 10.90 | 3.50 | 3.48 | 17.88 |
| 2000 | 34194.50 | 13.98 | 4.48 | 4.46 | 22.92 |
| 2001 | 42959.33 | 17.57 | 5.63 | 5.60 | 28.8 |
| 2002 | 52978.38 | 21.67 | 6.95 | 6.91 | 35.52 |
| 2003 | 64202.65 | 26.26 | 8.42 | 8.37 | 43.04 |
| 2004 | 76724.97 | 31.15 | 10.17 | 10.01 | 51.33 |
| 2005 | 90560.76 | 36.77 | 12.00 | 11.81 | 60.58 |
| 2006 | 105645.13 | 42.89 | 14.00 | 13.78 | 70.67 |
| 2007 | 121948.77 | 49.51 | 16.16 | 15.91 | 81.58 |
| 2008 | 139524.09 | 56.65 | 18.49 | 18.20 | 93.33 |
| 2009 | 158210.04 | 64.29 | 21.13 | 20.68 | 106.11 |
| 2010 | 177913.00 | 72.30 | 23.77 | 23.26 | 119.32 |
| 2011 | 198587.36 | 80.70 | 26.53 | 25.96 | 133.19 |
| 2012 | 220202.45 | 89.48 | 29.42 | 28.79 | 147.69 |
| 2013 | 242735.73 | 98.64 | 32.43 | 31.73 | 162.8 |
| 2014 | 266169.86 | 108.25 | 37.08 | 32.94 | 178.26 |

[190] *Andis Lazdiņš and Juris Zariņš, "Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol article 3.3 and 3.4 activities (Report on research work contracted by the Ministry of Environment of republic of Latvia)" (LVMI Silava, 2010).*

**Table 6.13 Harvesting stock, in 1000 m³**

| Year | Total excluding deforestation | Aspen | Grey alder | Birch | Spruce | Black alder | Oak, ash | Other | Pine |
|---|---|---|---|---|---|---|---|---|---|
| **1990** | 6297.55 | 568.35 | 405.01 | 1827.46 | 1355.42 | 109.19 | 24.32 | 0.01 | 2007.79 |
| **1991** | 5531.97 | 499.26 | 355.78 | 1605.3 | 1190.64 | 95.92 | 21.36 | 0.01 | 1763.71 |
| **1992** | 5056.33 | 456.33 | 325.19 | 1467.27 | 1088.27 | 87.67 | 19.53 | 0.01 | 1612.06 |
| **1993** | 5991.69 | 540.75 | 385.34 | 1738.7 | 1289.59 | 103.89 | 23.14 | 0.01 | 1910.28 |
| **1994** | 7217.00 | 651.33 | 464.15 | 2094.27 | 1553.31 | 125.13 | 27.87 | 0.01 | 2300.93 |
| **1995** | 8672.69 | 782.71 | 557.77 | 2516.69 | 1866.62 | 150.37 | 33.49 | 0.01 | 2765.04 |
| **1996** | 8519.11 | 768.85 | 547.89 | 2472.12 | 1833.56 | 147.71 | 32.9 | 0.01 | 2716.07 |
| **1997** | 11239.43 | 1014.36 | 722.84 | 3261.52 | 2419.05 | 194.88 | 43.41 | 0.01 | 3583.36 |
| **1998** | 12632.65 | 1140.1 | 812.44 | 3665.81 | 2718.91 | 219.03 | 48.79 | 0.02 | 4027.55 |
| **1999** | 16925.69 | 1527.54 | 1088.54 | 4911.59 | 3642.9 | 293.47 | 65.36 | 0.02 | 5396.26 |
| **2000** | 13855.70 | 1269.63 | 666.58 | 4099.53 | 3867.38 | 0.00 | 50.45 | 0.00 | 3902.15 |
| **2001** | 13037.03 | 1235.76 | 593.86 | 3613.68 | 3394.98 | 233.06 | 34.57 | 0.00 | 3931.13 |
| **2002** | 14090.92 | 1399.42 | 816.16 | 3979.92 | 3512.58 | 223.99 | 40.51 | 0.00 | 4118.34 |
| **2003** | 14599.66 | 1473.65 | 996.39 | 3944.79 | 3300.02 | 231.89 | 48.93 | 0.00 | 4604 |
| **2004** | 13542.74 | 1282.88 | 1075.65 | 3795.57 | 2934.95 | 246.67 | 45.72 | 0.00 | 4161.3 |
| **2005** | 14209.18 | 847.32 | 839.85 | 3597.28 | 3705.24 | 261.3 | 83.08 | 0.00 | 4875.1 |
| **2006** | 12340.08 | 1180.35 | 860.65 | 3561.31 | 2380.31 | 255.29 | 52.55 | 0.00 | 4049.62 |
| **2007** | 12752.59 | 1178.77 | 1076.25 | 3854.25 | 2548.87 | 254.88 | 64.54 | 0.19 | 3774.86 |
| **2008** | 11287.94 | 990.28 | 894.22 | 3294.99 | 1982.87 | 256.93 | 46.12 | 0.00 | 3822.53 |
| **2009** | 13512.24 | 1214 | 767.53 | 3959.2 | 2155.57 | 254.86 | 55.14 | 0.00 | 5105.93 |
| **2010** | 16349.84 | 1424.07 | 1036.82 | 5710.6 | 2397.14 | 374.76 | 56.47 | 0.00 | 5349.99 |
| **2011** | 16021.22 | 1427.85 | 1247.55 | 4373.28 | 2738.8 | 280.85 | 83.37 | 10.64 | 5858.88 |
| **2012** | 14769.69 | 1170.11 | 4402.3 | 1257.07 | 2372.49 | 219.03 | 57.44 | 10.81 | 5280.43 |
| **2013** | 14685.05 | 1188.45 | 4311.92 | 1305.46 | 2413.89 | 285.54 | 76.3 | 9.63 | 5093.86 |
| **2014** | 16565.55 | 1725.32 | 2713.66 | 3185.66 | 2592.08 | 434.41 | 85.75 | 786.25 | 5199.67 |

The total area of the Land converted to forest is shown in Table 6.14 and Table 6.15. In 2010 it start to reduce, because area afforested in 1990-1993 in the convention reporting is accounted under the forest land remaining forest land category.

**Table 6.14 Total area of the land converted to forest, 1000 ha**

| Year | Land converted to forest at the end of year | Forest on dry mineral soils | Forest on drained mineral soils | Forest on wet mineral soils | Forest on drained organic soils | Forest on wet organic soils |
|---|---|---|---|---|---|---|
| **1990** | 4.66 | 3.97 | 0.38 | 0.26 | 0.00 | 0.05 |
| **1991** | 11.50 | 8.31 | 2.12 | 0.62 | 0.40 | 0.05 |
| **1992** | 20.73 | 15.66 | 2.94 | 1.31 | 0.76 | 0.05 |
| **1993** | 31.43 | 23.86 | 4.29 | 1.67 | 1.16 | 0.45 |
| **1994** | 40.11 | 28.63 | 7.46 | 2.07 | 1.16 | 0.79 |
| **1995** | 53.20 | 38.79 | 10.00 | 2.07 | 1.56 | 0.79 |
| **1996** | 67.59 | 50.05 | 11.68 | 2.71 | 2.36 | 0.79 |
| **1997** | 80.71 | 60.37 | 12.16 | 3.62 | 3.37 | 1.19 |
| **1998** | 94.67 | 70.72 | 13.22 | 4.79 | 4.09 | 1.85 |
| **1999** | 107.17 | 81.31 | 15.12 | 4.79 | 4.09 | 1.85 |
| **2000** | 121.38 | 92.84 | 15.92 | 5.69 | 4.86 | 2.06 |
| **2001** | 137.48 | 105.86 | 18.74 | 5.89 | 4.92 | 2.06 |
| **2002** | 151.14 | 117.93 | 19.86 | 6.37 | 4.92 | 2.06 |
| **2003** | 161.88 | 126.77 | 21.57 | 6.37 | 5.12 | 2.06 |
| **2004** | 176.51 | 139.38 | 22.16 | 6.89 | 6.01 | 2.06 |
| **2005** | 188.98 | 149.96 | 23.47 | 7.29 | 6.2 | 2.06 |

| Year | Land converted to forest at the end of year | Forest on dry mineral soils | Forest on drained mineral soils | Forest on wet mineral soils | Forest on drained organic soils | Forest on wet organic soils |
|---|---|---|---|---|---|---|
| **2006** | 198.37 | 157.88 | 24.58 | 7.29 | 6.57 | 2.06 |
| **2007** | 207.56 | 164.11 | 26.02 | 8.41 | 6.57 | 2.46 |
| **2008** | 218.93 | 174.03 | 26.82 | 8.41 | 6.97 | 2.71 |
| **2009** | 222.81 | 177.11 | 27.29 | 8.56 | 7.09 | 2.76 |
| **2010** | 226.68 | 180.19 | 27.77 | 8.71 | 7.21 | 2.8 |
| **2011** | 230.55 | 183.27 | 28.24 | 8.86 | 7.34 | 2.85 |
| **2012** | 234.42 | 186.35 | 28.71 | 9.0 | 7.46 | 2.9 |
| **2013** | 238.30 | 189.42 | 29.19 | 9.15 | 7.58 | 2.95 |
| **2014** | 242.17 | 192.5 | 29.66 | 9.3 | 7.71 | 3.0 |

**Table 6.15 Area of the land converted to forest more than 20 years ago, 1000 ha**

| Year | Land converted to forest > 20 years ago | Forest on dry mineral soils | Forest on drained mineral soils | Forest on wet mineral soils | Forest on drained organic soils | Forest on wet organic soils |
|---|---|---|---|---|---|---|
| **2010** | 4.66 | 3.97 | 0.38 | 0.26 | 0.00 | 0.05 |
| **2011** | 11.50 | 8.31 | 2.12 | 0.62 | 0.40 | 0.05 |
| **2012** | 20.73 | 15.66 | 2.94 | 1.31 | 0.76 | 0.05 |
| **2013** | 31.43 | 23.86 | 4.29 | 1.67 | 1.16 | 0.45 |
| **2014** | 40.11 | 28.63 | 7.46 | 2.07 | 1.16 | 0.79 |

## 6.4.2 Methodological issues

### 6.4.2.1 Forest land remaining forest land (CRF 4.A.1)

Calculations of carbon stock changes and GHG emissions in forest lands are based on activity data provided by the NFI (area, living biomass and dead wood) and Level I forest monitoring data (soil organic carbon). National statistics (State forest service) are used to estimate commercial felling related emissions and removals. The calculation of GHG emissions and $CO_2$ removals in historical forest lands is based mainly on research report "Elaboration of the model for calculation of the $CO_2$ removals and GHG emissions due to forest management"[191] and factors and coefficients elaborated within the scope of the research program on impact of forest management on GHG emissions and $CO_2$ removals[192].

Changes of the carbon stock and GHG emissions are estimated according to the Tier 2 methods with country specific data. Default method (the carbon loss to be subtracted from the carbon removals for the reporting year) is used in calculations of removals and emissions of $CO_2$ in living biomass.

Methodologies for estimation of carbon stock changes and GHG emissions are considerably improved; they are now merged together into the "Emissions projection & inventory model (EPIM)", which is complex spreadsheet. Separate versions (with different input data) are elaborated for the UNFCCC and the Kyoto protocol reporting. In future these tools will be

[191] *Lazdiņš, A., Donis, J., Strūve, L., 2012. Latvijas meža apsaimniekošanas radītās ogļskābās gāzes ($CO_2$) piesaistes un siltumnīcefekta gāzu (SEG) emisiju references līmeņa aprēķina modeļa izstrāde (Elaboration of the model for calculation of the $CO_2$ removals and GHG emissions due to forest management) ( No. 5.5-9.1-0070-101-12-91). LVMI Silava, Salaspils. Lazdiņš, A., Donis, J., Strūve, L., 2012b. Latvia's national methodology for reference level of forest management activities (English summary).*

[192] *Lazdiņš et al., Mežsaimniecisko Darbību Ietekmes Uz Siltumnīcefekta Gāzu Emisijām Un $CO_2$ Piesaisti Novērtējums (pārskats Par 2013. Gada Darba Uzdevumu Izpildi).*

merged to simplify calculations. The tool is still under development, current working version can be downloaded from the website "Land use, land use change and forestry sector in Latvia"[193].

The concept of the EPIM:

Land use and land use change data are elaborated separately to simplify tool structure, the connection is organized as linked tables;

- main input data – area under different growth and management conditions, species composition, gross annual increment, mortality per area, harvesting rate and species composition and others;
- calculations are done on annual basis using periodic (5 years period) and annual input data;
- historical data (1990-2004) – backward calculation on the base of the NFI data; for 1970-1989 research data and expert judgements are utilized;
- all modules in the spreadsheet are merged together following to the forest management cycle (from growth to decay);
- the tool combines all land use and land use change categories.

Content of the tool (separate calculation sheets):

- living biomass (annual increment of living biomass, summary of growing stock and characteristics of biomass);
- mortality (natural reduction of number of living trees, estimation of decay of harvesting residues, calculation of dynamics of carbon stock in dead biomass);
- commercial harvesting (input to the harvested wood products, losses in above-ground and below-ground biomass);
- harvested wood products (carbon stock change in locally originated and consumed harvested wood products);
- emissions from soils ($CO_2$, $CH_4$ and $N_2O$ from drained organic soils and $CH_4$, DOC, $CO_2$ emissions from rewetted soils in forest land and wetlands);
- fire (emissions of $CO_2$, $CH_4$ and $N_2O$ due to incineration of harvesting residues and wildfires);
- conversion from forests (as a land use change to estimate area of managed forests);
- afforestation (carbon stock change in living biomass, dead wood and litter);
- cropland (emissions from soil, carbon stock change in living and dead biomass);
- grassland (emissions from soil, carbon stock change in living and dead biomass, wildfires);
- conversion of farmland (emissions or removals in soil);

[193] *https://drive.google.com/folderview?id=0Bxv4jQ_04jXZNTM5aGNDTVdRVzQ&usp=sharing*

- settlements (carbon stock change in soil, living and dead biomass);
- managed wetlands (emissions from soil, carbon stock change in living and dead biomass).

Module for estimation of the gross annual increment of living biomass:

- increment figures on the base of the NFI data on timber stock changes and mortality rate[194];
- species, age of stands and dimensions specific gross increment equations for the most common tree species (values specific for birch are used for other tree species);
- species specific wood densities (Table 6.16), different BEFs (Table 6.17);
- average carbon stock in biomass is provided in Table 6.18.

The figures in are based on stock change in forest stands with different dominant species.

**Table 6.16 Wood density[195]**

| Species | Density, tonnes $m^{-3}$ |
|---|---|
| **Aspen** | 0.40 |
| **Grey alder** | 0.41 |
| **Birch** | 0.47 |
| **Spruce** | 0.36 |
| **Black alder** | 0.41 |
| **Oak, ash** | 0.41 |
| **Other species (mostly *Salix* sp.)** | 0.41 |
| **Pine** | 0.38 |

**Table 6.17 Coefficients for calculation of above ground biomass from stem biomass**

| Species | Stem biomass to crown biomass | Stem biomass to below-ground biomass |
|---|---|---|
| **Aspen** | 1.22 | 0.28 |
| **Grey alder** | 1.45 | 0.34 |
| **Birch** | 1.19 | 0.29 |
| **Spruce** | 1.58 | 0.43 |
| **Black alder** | 1.45 | 0.28 |
| **Oak, ash** | 1.45 | 0.18 |
| **Other species** | 1.45 | 0.27 |
| **Pine** | 1.27 | 0.31 |

194 *Jānis Donis, Latvijas Meža Resursu Ilgtspējīgas, Ekonomiski Pamatotas Izmantošanas Un Prognozēšanas Modeļu Izstrāde (Salaspils: LVMI Silava, 2011), http://www.zm.gov.lv/doc_upl/MAF2011_S82.pdf; Lazdiņš, Donis, and Strūve, Latvijas Meža Apsaimniekošanas Radītās Ogļskābās Gāzes ($CO_2$) Piesaistes Un Siltumnīcefekta Gāzu (SEG) Emisiju References Līmeņa Aprēķina Modeļa Izstrāde.*

195 *Lazdiņš et al., Mežsaimniecisko Darbību Ietekmes Uz Siltumnīcefekta Gāzu Emisijām Un $CO_2$ Piesaisti Novērtējums (pārskats Par 2013. Gada Darba Uzdevumu Izpildi).*

**Table 6.18 Average carbon stock in living biomass**

| Species | C, kg in tonne of dry biomass[196] |
|---|---|
| **Aspen** | 508 |
| **Grey alder** | 522 |
| **Birch** | 521 |
| **Spruce** | 528 |
| **Black alder** | 522 |
| **Oak, ash** | 522 |
| **Other species** | 522 |
| **Pine** | 531 |

Mortality and decay:

- species specific coefficients of mortality (Table 6.19) not dependant on size of tree (dominant or undergrowth trees), depend on the age of stand and average dimensions of trees;
- calculations on the base of NFI using backward calculation for 5 years period, assuming equal rate of commercial thinning in the 1990s;
- 20 years decomposition period (mortality since 1970 considered as emissions);
- constant mortality values considered for periods before 1990.

**Table 6.19 Average periodic mortality ($m^3$ $ha^{-1}$ $yr^{-1}$)[197]**

| Species | 1970-1993 | 1994-1998 | 1999-2003 | 2004-2008 | 2009-2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| Aspen | 1.97 | 2.35 | 2.37 | 2.32 | 2.32 | 2.94 | 2.97 |
| Grey alder | 0.36 | 0.40 | 0.43 | 0.58 | 0.58 | 2.60 | 2.54 |
| Birch | 1.92 | 2.01 | 1.90 | 1.72 | 1.72 | 2.17 | 2.10 |
| Spruce | 1.95 | 2.12 | 2.33 | 2.48 | 2.48 | 3.00 | 2.77 |
| Black alder | 1.57 | 1.71 | 1.78 | 1.98 | 1.98 | 2.58 | 2.65 |
| Oak, ash | 2.76 | 3.20 | 3.21 | 3.46 | 3.46 | 4.84 | 4.88 |
| Other species | 0.90 | 0.79 | 0.81 | 0.93 | 0.93 | 2.79 | 1.70 |
| Pine | 1.39 | 1.49 | 1.66 | 1.78 | 1.78 | 1.67 | 1.79 |

Commercial felling:

- dominant species specific harvesting data since 1970 (1990-2013 Central statistical bureau updated by NFI data, 2014 NFI, 1970-1989 research papers[198]);
- decomposition of crown and underground biomass – 20 years; species specific wood densities and different BEFs for coniferous and deciduous trees (Table 6.16 and Table 6.17).

The methodology for harvested wood products is based on Rüter, S., 2011[199]. More detailed description follows in further chapters.

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[196] *Dried at 105 °C temperature.*

[197] *Lazdiņš et al., Mežsaimniecisko Darbību Ietekmes Uz Siltumnīcefekta Gāzu Emisijām Un $CO_2$ Piesaisti Novērtējums (pārskats Par 2013. Gada Darba Uzdevumu Izpildi); Lazdiņš, Donis, and Strūve, Latvijas Meža Apsaimniekošanas Radītās Ogļskābās Gāzes ($CO_2$) Piesaistes Un Siltumnīcefekta Gāzu (SEG) Emisiju References Līmeņa Aprēķina Modeļa Izstrāde.*

[198] *Zigurds Saliņš, Mežs - Latvijas Nacionālā Bagātība (Jelgava: Jelgavas tipogrāfija, 2002); Zigurds Saliņš, Meža izmantošana Latvijā: stāvoklis, perspektīvas (Jelgava [Latvia]: LLU Meza izmantosanas katedra, 1999).*

Emissions from drained soils are accounted – 2.6 tonnes C $ha^{-1}$ and 2.8 kg $N_2O$-N $ha^{-1}$ (IPCC Wetlands Supplement) annually from organic soils.

Area of organic soils in the forest lands is reported according to structure of distribution of the forest stand types. Total area of organic soils as well as total area of forests was updated according to research data on land use structure according to the NFI[200].

New project was implemented in 2014 to estimate carbon stock change in organic forest soil due to establishment of drainage system[201]. The empiric material is collected in experimental trials established in early 60[ths]. According to the study results no soil carbon losses take place due to drainage of organic soil in comparison to naturally wet site; however, more experimental data are necessary to extrapolate these results to the whole area of Latvia.

Drained organic soil in forest land is source of $CH_4$ emissions. $CH_4$ emissions are calculated by equation 2.6 in IPCC Wetlands Supplement (equation No. 1 in the NIR).

$$CH_{4\_organic} = A * \left( \left(1 - Frac_{ditch}\right) * EF_{CH\_4\_land} + Frac_{ditch} * EF_{CH\_4\_ditch} \right);\ where$$

$CH_{4\_organic}$ – annual $CH_4$ loss from drained organic soils, kg $CH_4\,yr^{-1}$

$A$ – land area of drained organic soils in a land – use category, ha

$EF_{CH\_4\_land}$ – emission factor for direct $CH_4$ emissions from drained organic soils, kg $CH_4\,ha^{-1}\,yr^{-1}$

$EF_{CH\_4\_ditch}$ – emission factor for $CH_4$ emissions from drainage ditches, kg $CH_4\,ha^{-1}\,yr^{-1}$

$Frac_{ditch}$ – fraction of the total area of drained organic soil which is ocupied by ditches (1)

The $CH_4$ emission factor for organic soils of drained forest land (Table 2.3 and Table 2.4 in IPCC Wetlands Supplement) is 2.5 kg $CH_4$ $ha^{-1}$ $yr^{-1}$ and emission factor for drainage ditches is 217 kg $CH_4$ $ha^{-1}$ $yr^{-1}$. Data for fraction of drainage ditches of total drained area on organic soils is obtained by evaluation fraction of ditches in state managed forest lands to all drained forest organic soils.

GHG emissions from rewetted organic soils are estimated according to the Tier 1 methods. $CO_2$ emissions are calculated using equation 3.3:

$$CO_2 - C_{rewetted\ org\ soil} = CO_2 - C_{composite} + CO_2 - C_{DOC};\ where$$

$CO_2 - C_{rewetted\ org\ soil}$ – $CO_2 - C$ emissions / removals from rewetted organic soils, tonnes C $yr^{-1}$

$CO_2 - C_{composite}$ – $CO_2 - C$ emissions / removals from the soil and non – tree vegetation, tonnes C $yr^{-1}$

$CO_2 - C_{DOC}$ – off – site $CO_2 - C$ emissions from dissolved organic carbon exported from rewetted organic soils, tonnes C $yr^{-1}$ (2)

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[199]*Projection of Net Emissions from Harvested Wood Products in European Countries, Johann Heinrich von Thünen Institute, Hamburg.*

[200]*Lazdiņš and Zariņš, "Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol article 3.3 and 3.4 activities (Report on research work contracted by the Ministry of Environment of republic of Latvia)."*

[201]*Andis Lazdiņš, Aldis Butlers, and Ainārs Lupiķis, "Case Study of Soil Carbon Stock Changes in Drained and Afforested Transitional Bog," in Foresst Ecosystems and Its Management: Towards Understanding the Complexity (presented at the 9th Baltic theriological conference, Ilgas: Latvian State Forest Research Institute "Silava," 2014); Andis Lazdiņš and Ainārs Lupiķis, Hidrotehniskās Meliorācijas Ietekme Uz $CO_2$ Emisijām Mežaudzēs Uz Susinātām Augsnēm (Salaspils, 2014), Salaspils.*

complemented by equations 3.4 and 3.5 of the IPCC Wetlands Supplement.

$$CO_2 - C_{composite} = \sum_{c,n} \left(A * EF_{CO2}\right); \; where$$

$A_{c,n}$ – area of rewetted organic soils in climate zone c and nutrient status n, ha

$EF_{CO2c,n}$ – $CO_2 - C$ emission factor for rewetted organic soils in climate zone c, nutrient status n, tonnes C $ha^{-1}$ $yr^{-1}$

(3)

$$CO_2 - C_{DOC} = \sum_{c} \left(A * EF_{DOC\_REWETTED}\right); \; where$$

$A_c$ – area of rewetted organic soils in climate zone c, ha

$EF_{DOC\_rewetted,c}$ – $CO_2 - C$ emission factor from DOC exported from rewetted organic soils in climate zone c, tonnes C $ha^{-1}$ $yr^{-1}$

(4)

Emission factors for $CO_2$-C (0.5 tonnes $CO_2$-C $ha^{-1}$ $yr^{-1}$) and DOC (0.24 tonnes $CO_2$-C $ha^{-1}$ $yr^{-1}$) are taken from Tables 3.1 and 3.2 of the IPCC Wetlands Supplement. $N_2O$ emissions from rewetted organic soils according to Tier 1 method are assumed to be negligible and are not estimated, $CH_4$ emissions are calculated applying Tier 1 method using equation 3.7 of the IPCC Wetlands Supplement (equation No. 5). Default emission factor (216 kg $CH_4$-C $ha^{-1}$ $yr^{-1}$) from Table 3.3 was used (Table 6.20).

$$CH_4 - C_{rewetted\ org\ soil} = \frac{\sum_{c,n} \left(A * EF_{CH4soil}\right) c,n}{1000}; \; where$$

$CH_4 - C_{rewetted\ org\ soil}$ – $CH_4 - C$ emissions/removals from rewetted organic soils, tonnes C $yr^{-1}$

$A_c$, n – area of rewetted organic soils in climate zone c and nutrient status n, ha

$EF_{CH4soil}$ – emission factor from rewetted organic soils in climate zone c and nutrient status n, kg $CH_4 - C$ $ha^{-1}$ $yr^{-1}$

(5)

**Table 6.20 Emission factors for rewetted organic soils, tonnes C $ha^{-1}$ $yr^{-1}$**

| No | GHG | Emission factor |
|---|---|---|
| **1** | $CO_2$ | 0.5 |
| **2** | $CH_4$ | 0.216 |

Rewetting is reported under forest land – conversion of forests on drained organic soils to forest on naturally wet soil. The conversion is usually approved by changes in ground vegetation and groundwater table during the site visits. Rewetting takes place due to wearing of drainage systems. In 2014, total rewetted area according to comparison of the NFI data is 12.04 kha. It is assumed, that the rewetting was linear and 2 kha of forests were rewetted every year from 2009 to 2014 according to an average figures for 2009-2013 provided by the NFI and linear extrapolation of 5 years average in 2014. Total emissions from soil due to rewetting in 2014 approached to 108.7 kt $CO_2$ eq. (Figure 6.3).

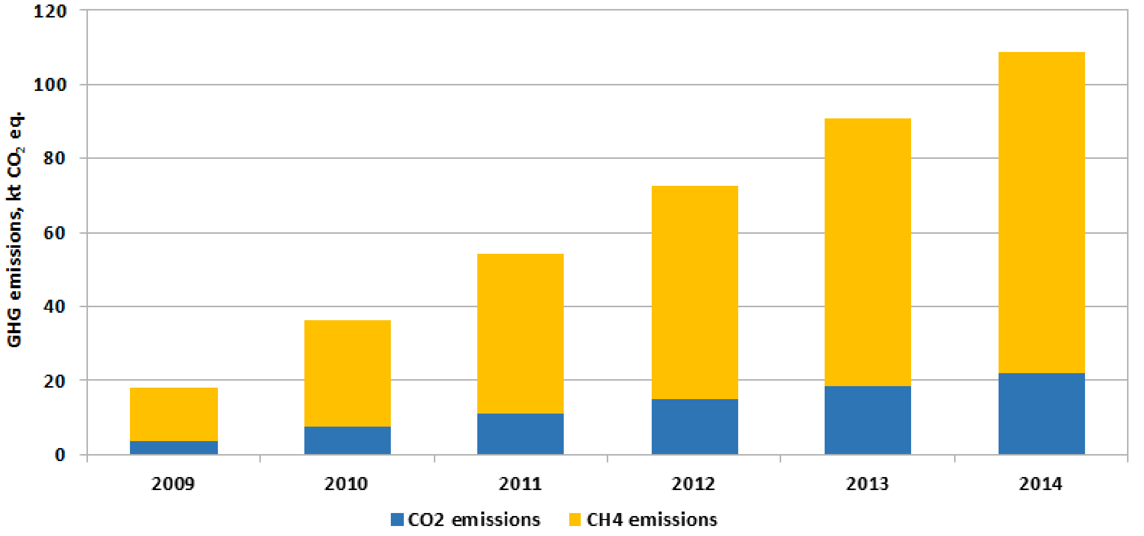


**Figure 6.3 Emissions due to rewetting (kt $CO_2$ eq.)**

### 6.4.2.2 Land converted to forest land (CRF 4.A.2)

In section lands converted to forest land all categories except grasslands converted to forest land are noted as NO because other conversions do not take place in practice. Grasslands converted to forest land are estimated using spatial approach – analysis of the NFI data about forests on former farmland (land being cropland and grassland before 1990) which was afforested after 1990. Areas where trees did not reach 2 cm diameter at breast height were excluded from estimation and accounted under grassland category to avoid accounting of extensively managed farmlands under forest land category. The year of afforestation of every single NFI plot selected for analysis was determined by subtraction of age of stand from a year when field measurements were done.

Gains in living biomass on afforested lands are estimated using interpolation (stock change method assuming that the increment structure in areas afforested in different periods is similar)[202]. Weighted average wood density for a particular year in forest land remaining forest is used to convert stem volume to biomass. Similarly, average carbon stock in living biomass and BEFs characteristic for particular year were applied to calculation. 2015 is the second year, when, both, carbon stock change in living biomass in land remaining forest and land converted to forest is calculated using Tier 2 method.

Losses of living biomass in afforested lands are noted as NO because no commercial felling takes place in these stands (the smallest commercially and legally valuable harvesting age is 30 years for grey alder).

Emissions from organic soils in afforested lands were calculated using the same approach as for emissions from drained organic soils on lands remaining forest.

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[202] *L.U. Consulting, "Augšņu un reljefa izejas datu sagatavošana un Eiropas Komisijas izstrādāto augsnes un reljefa kritēriju mazā labvēlīgo apvidu noteikšanai piemērošanas simulācija (Projekta kopsavilkuma ziņojums)" (Elaboration of soil and terrain data and simulation of application of the criteria elaborated by the European Commission for identification of less valuable regions (Summary of the project report)), Latvijas Republikas Zemkopības Ministrija, 2010.*

This is the second year when dead wood and litter are accounted as sink categories in afforested lands. It is assumed that average stock of dead wood, and consequently in litter in historical forest lands and afforested lands becomes equal at certain stand age. The assumption is based on the NFI field measurements considering that increment of the dead wood stock in afforested areas will follow linear regression and will reach values characteristic for the forest land within 150 years.

It is assumed in the calculation, that dead wood stock in afforested lands will reach 1.1 tonnes C $ha^{-1}$ within 150 years. Values of average carbon stock in dead wood in 1990-2014 were used in calculation. Similarly, weighted average above-ground and below-ground biomass expansion factors and carbon content in living biomass for a particular year obtained in living biomass calculations are used to convert stem biomass to the total biomass.

Average carbon stock in litter is 12.1 tonnes C $ha^{-1}$ according to the BioSoil project forest soil inventory data[203]. Considering the same transformation period of 150 years, average increment of carbon stock in the litter carbon pool is 0.08 tonnes C $ha^{-1}$.

No removals in soil are accounted due to conversion to forest land, because there are no scientific evidences of increase of carbon stock in soil after afforestation. The project started in 2012 on comparison of carbon stock in historical cropland and grassland shows no difference in carbon stock between grassland, recently afforest land and historical forest land in the upper soil layer (0-40 cm)[204]; however, there are evidences of statistically significant carbon stock changes in deeper soils layers after afforestation[205].

### 6.4.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainties are estimated on the base the NFI and expert judgement. Uncertainty of soil carbon ($CO_2$) emissions are estimated according to data obtained within the scope of the international forest soil monitoring project BioSoil and values provided in the IPCC Wetlands Supplement. The uncertainty of $CO_2$ emission factor according to IPCC Wetlands Supplement (Table 2.1) in organic soil is 25 %.

The uncertainty of area (Table 6.21) is estimated as standard error of proportion (equation No. 10).

[203] *Bārdule et al., "Forest soil characteristic in Latvia according results of the demonstration project BioSoil (Latvijas meža augsņu īpašību raksturojums demontrācijas projekta BioSoil rezultātu skatījumā)."*

[204] *Andis Lazdiņš, Atbalsts Klimata Pētījumu Programmai (starpziņojums Par 2012. Gada Darba Uzdevumu Izpildi) (Salaspils: LVMI Silava, 2012), https://sites.google.com/site/lvlulucf/research-projects/atbalstsklimatapetijumuprogrammaistarpzinojumspar2012gadarezultatiem.*

[205] *R. Kasparinskis et al., "Long term impact of afforestation on soil morphology and properties, Lauksaimniecības zemju apmežošanās ilgtermiņa ietekme uz augsnes morfoloģiju un īpašībām," Forest science no. 24(57) p. 17–40 (2011), http://agris.fao.org/agris-search/search/display.do?f=2012%2FLV%2FLv1203.xml%3BLV2012000112.*

**Table 6.21 Uncertainty of the forest land use data in 2014**

| Land use category | Number of NFI plots | Share of NFI plots, % | Uncertainty, % |
|---|---|---|---|
| **Forest land** | 8322 | 51.5 | 1.5 |
| **forest land remaining forest land** | 7885 | 48.8 | 1.6 |
| **drained organic soil** | 1116 | 6.9 | 5.3 |
| **other soil** | 5040 | 31.2 | 2.3 |
| **land converted to forest land** | 437 | 2.7 | 8.0 |
| **drained organic soil** | 10 | 0.1 | 43.5 |
| **other soil** | 380 | 2.4 | 8.7 |

Uncertainty of annual increment of growing stock of trees in forest lands is 0.9 %, uncertainty of increment on afforested lands 16 %. Uncertainties calculated according to 2006 IPCC Guidelines Volume 1, Chapter 3 as twice the relative standard error. For harvesting stock, uncertainty according to forest regulations is 10 %. BEFs utilized in calculations according to expert judgement have uncertainty level of 0.9-2.0 % for different species, 0.8 % in average according to the study results. Combined category uncertainty is calculated according to 2006 IPCC Guidelines TIER 1 – simple propagation of errors.

95 % confidence interval for $CH_4$ emission factor for drained organic soil of forest land is -0.6-+5.7 kg $CH_4$ $ha^{-1}$ $yr^{-1}$. Uncertainty range of $CH_4$ emission factor for drainage ditches in drained forest land is 41-393 kg $CH_4$ $ha^{-1}$ $yr^{-1}$ (IPCC Wetlands Supplement, Table 2.3 and Table 2.4).

Uncertainty range of $CO_2$-C emission factor for rewetted organic soils is -0.71-+1.71 tonnes $CO_2$-C $ha^{-1}$ $yr^{-1}$ (IPCC Wetlands Supplement, Table 3.1). Uncertainty range of $CO_2$-C emission factor from DOC exported from rewetted organic soils is 0.14-0.36 tonnes $CO_2$-C $ha^{-1}$ $yr^{-1}$ (IPCC Wetlands Supplement, Table 3.2). 95% range of $CH_4$-C emission factor from rewetted organic soils is 0-856 kg $CH_4$-C $ha^{-1}$ $yr^{-1}$ (IPCC Wetlands Supplement, Table 3.3).

### 6.4.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

Quality control procedures listed in 2006 IPCC Guidelines Chapter 4.4.3 were implemented for all calculations, including elaboration of country specific BEFs, wood density and carbon content factors. Several quality meetings are held annually between experts.

The NFI data have gone through the following QC measures:

- field gauges and instruments were checked and calibrated;
- new instruments were tested to find possible differences in measurement results compared with the old ones;
- before field surveying, field personnel has had a training period to ascertain that observers are able to use the equipment correctly, that observers do measurements and classifications correctly and that the guidelines and instructions are understood correctly;
- verification measurements were carried out during field seasons;

- field data are checked by evaluation if all sample plots are measured, no required information is missing (if missing entries are found, they are completed and re-measurement is done, if necessary), the compatibility between data variables is checked using logical controls;
- calculated results are compared with the results of previous inventories. If considerable or unexpected changes are found, reasons for the changes were clarified and explained.

Work on improvement of tree height and timber equations used in calculations in the NFI and development of verification tools continues therefore changes in the input data provided by the NFI are possible.

The NFI team applies quality guidelines and QA/QC measures to the all work stages. Documentation is in Latvian with brief descriptions of NFI methods and measurements in English[206].

The data based on forest statistics were produced by the LSFRI Silava[207]. Data descriptions are available including the applied definitions, methods of data compilation, reliability and comparability. It was confirmed that all data used in this section cover whole land area of Latvia.

### 6.4.5 Category-specific recalculations

Recalculations are done due to recalculation of the NFI data based on repeated measurement of borders of the plots and their sectors. Summary of the impact of recalculation on the aggregated net GHG emissions from forest land is shown in Figure 6.4.

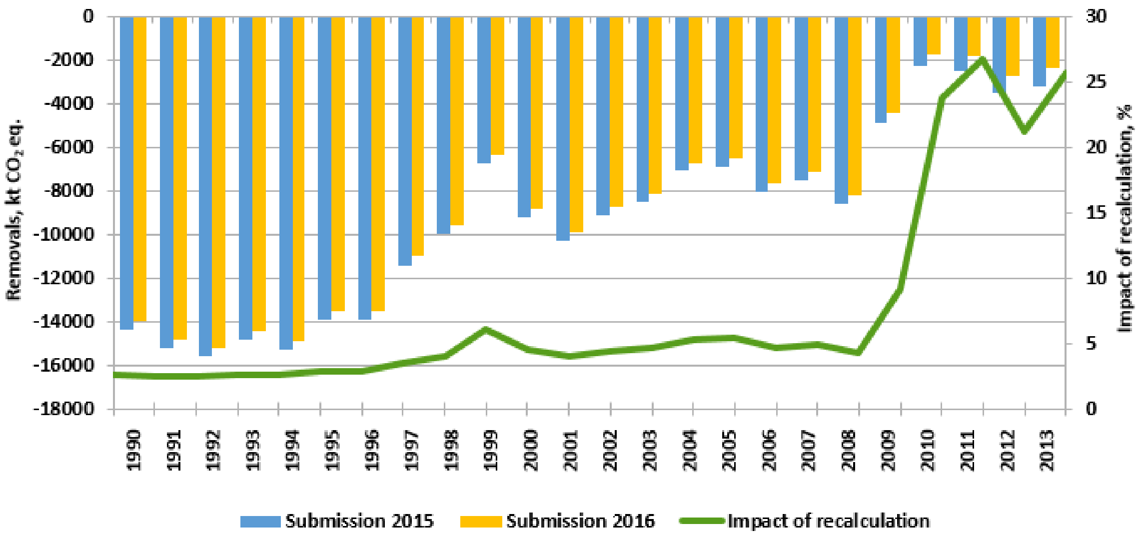


**Figure 6.4 Impact of recalculation on the aggregated net GHG emissions from forest land**

[206]*Zemkopības ministrija, "Meža statistiskās inventarizācijas veikšanas un mežaudzes sekundāro parametru aprēķināšanas metodika (instrukcija Nr. 10 no 17.03.2004.)" (Latvijas Republikas Zemkopības ministrija, 2004),https://sites.google.com/site/lvlulucf/literature/MSI_metodika_Instrukcija_%282004%29.pdf?attredirects=0&d=1; LSFRI Silava, "Methods utilized to recalculate historical forest increment data" (LSFRI Silava, 2007), https://sites.google.com/site/lvlulucf/literature/Recalculationsofhystoricalremovals2007.pdf?attredirects=0&d=1.*
[207]*http://www.silava.lv/userfiles/file/2010%20nov%20MRM_visi%20mezi_04-08g.xls*

### 6.4.6 Category-specific planned improvements

The most important planned improvements:

- estimation of decay period for dead wood (harvesting residues and below-ground biomass, planned to complete until report 1990-2015);
- estimation of carbon stock changes in drained organic soils in forest lands (2016);
- estimation of transition period for dead wood and litter carbon stock in afforested lands (2015-2018);
- development of production version of EPIM tool, including instantaneous calculation of uncertainties, broader representation of land use change options and closer integration of Kyoto protocol and the UNFCCC reporting (2016);
- improvement and simplification of structure of land use change calculation tool, including uncertainty estimates.

## *6.5 CROPLAND (CRF 4.B)*

### 6.5.1 Category description

Cropland remaining cropland and land converted to cropland is a key source category of $CO_2$ emissions. Under the cropland's category emissions from organic soils ($CO_2$, $N_2O$ and $CH_4$), living and dead woody biomass ($CO_2$) are reported. Net aggregated emissions from cropland remaining cropland were 2589.20 kt of $CO_2$ in 2014 (excluding 119.05 kt of $CO_2$ eq. emissions from drained organic soils, Figure 6.5). Decrease of $CO_2$ emissions in cropland remaining cropland is associated with land use change from cropland to grassland. The net GHG emissions from land converted to croplands in 2014 (excluding emissions from drainage of organic soils) were 182.15 kt $CO_2$ eq. (Figure 6.6).

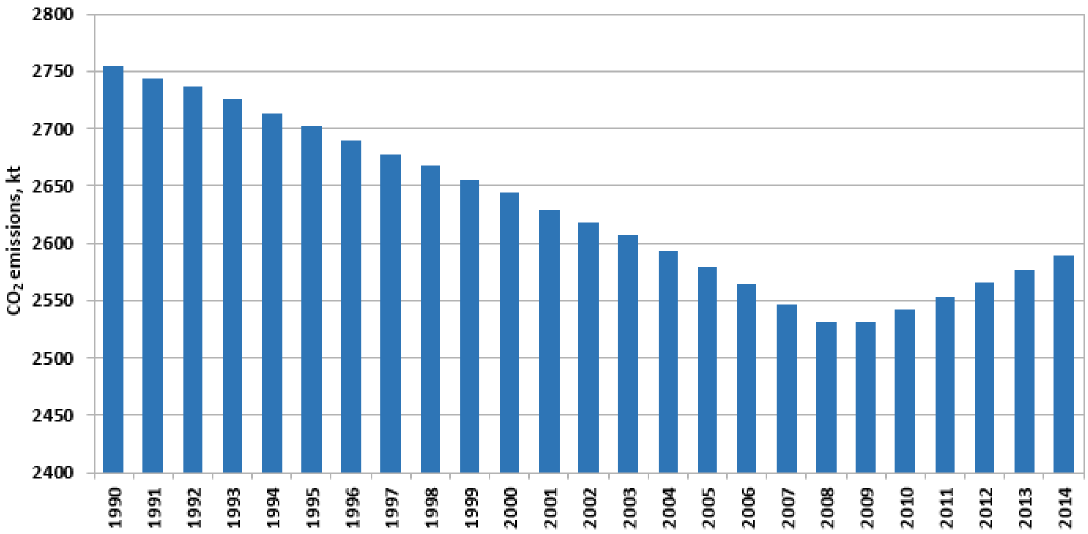


**Figure 6.5 Summary of $CO_2$ emissions in cropland remaining cropland (kt)**

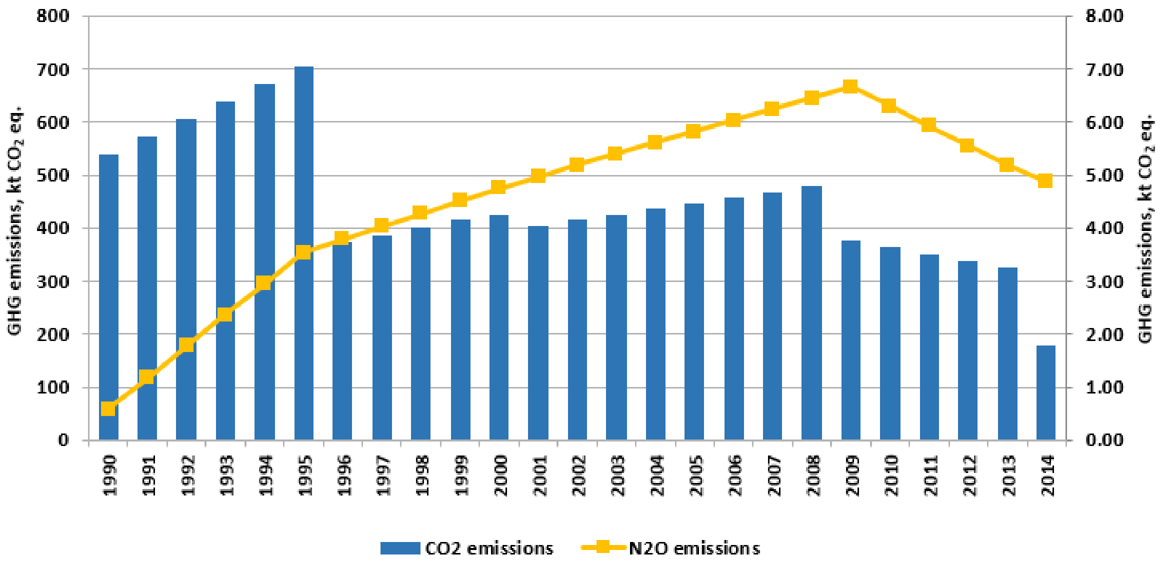


**Figure 6.6 Summary of GHG emissions from land converted to cropland[208] (kt $CO_2$ eq.)**

The total area of croplands is estimated using the approach described further in chapter Category-specific recalculations and following to research results. Updated values split into cropland remaining cropland, land converted to cropland at least 20 years ago and land converted to cropland less than 20 years ago are shown in Table 6.22. The land converted to cropland more than 20 years ago are reported under cropland remaining cropland category. The most of the land converted to cropland is forest land. Other types of land use changes have minor impact.

There is statistically significant increase of volume of growing stock of trees in cropland. After completion of the 2nd round of the NFI, the stock change method can be applied to characterize biomass of living trees in cropland on the base of stock changes during 5 years period.

**Table 6.22 Area of cropland (1000 ha)**

| Year | Cropland | Land remaining cropland | | Land converted to cropland | |
|---|---|---|---|---|---|
| | | organic soil | other soils | organic soil | other soils |
| **1990** | 1842.24 | 95.33 | 1745.00 | 0.43 | 1.48 |
| **1991** | 1837.27 | 94.97 | 1738.49 | 0.86 | 2.95 |
| **1992** | 1833.98 | 94.70 | 1733.56 | 1.29 | 4.43 |
| **1993** | 1828.93 | 94.34 | 1726.96 | 1.72 | 5.91 |
| **1994** | 1823.50 | 93.96 | 1720.00 | 2.15 | 7.39 |
| **1995** | 1817.85 | 93.57 | 1712.84 | 2.58 | 8.86 |
| **1996** | 1810.36 | 93.14 | 1704.99 | 2.76 | 9.47 |
| **1997** | 1802.95 | 92.72 | 1697.21 | 2.94 | 10.08 |
| **1998** | 1797.12 | 92.38 | 1690.94 | 3.12 | 10.69 |
| **1999** | 1789.13 | 91.92 | 1682.61 | 3.30 | 11.30 |
| **2000** | 1782.39 | 91.53 | 1675.48 | 3.48 | 11.91 |
| **2001** | 1773.20 | 91.02 | 1666.10 | 3.64 | 12.44 |

*[208] $N_2O$ on secondary axis*

| Year | Cropland | Land remaining cropland | | Land converted to cropland | |
|---|---|---|---|---|---|
| | | organic soil | other soils | organic soil | other soils |
| **2002** | 1766.53 | 90.64 | 1659.13 | 3.80 | 12.97 |
| **2003** | 1759.41 | 90.23 | 1651.72 | 3.96 | 13.50 |
| **2004** | 1750.97 | 89.76 | 1643.06 | 4.12 | 14.03 |
| **2005** | 1742.26 | 89.27 | 1634.15 | 4.28 | 14.56 |
| **2006** | 1733.30 | 88.77 | 1625.00 | 4.44 | 15.09 |
| **2007** | 1724.07 | 88.26 | 1615.59 | 4.60 | 15.62 |
| **2008** | 1714.58 | 87.73 | 1605.94 | 4.76 | 16.15 |
| **2009** | 1714.80 | 87.70 | 1605.33 | 4.87 | 16.90 |
| **2010** | 1715.02 | 87.67 | 1604.73 | 4.98 | 17.64 |
| **2011** | 1715.24 | 87.63 | 1604.12 | 5.09 | 18.40 |
| **2012** | 1715.45 | 87.60 | 1603.51 | 5.19 | 19.16 |
| **2013** | 1715.67 | 87.57 | 1602.90 | 5.28 | 19.93 |
| **2014** | 1715.89 | 87.53 | 1602.29 | 5.37 | 20.70 |

## 6.5.2 Methodological issues

### 6.5.2.1 Cropland remaining cropland (CRF 4.B.1)

Activity data for calculations are provided by research project[209] (area of organic soils). Area of land remaining cropland is estimated using remote sensing based research data[210] on the base of the NFI. Area of organic soils in farmland according to summaries of land surveys is 5.18 ± 0.5 %. This value characterizes area of cropland before 1990, because it is based on field measurements completed in 60ths, 70ths and early 80ths. It is assumed that share of organic soil in cropland remaining cropland, cropland converted to grassland, grassland converted to cropland and grassland remaining grassland is equal. Minor changes are introduced by conversion of forest land on organic soil to cropland and grassland. Therefore, the area of organic soil in cropland is linearly correlating with the total area of cropland. In 2014 according to this estimation there were 89.72 kha of organic soil in cropland remaining cropland and 3.34 kha in land converted to cropland. The study data on distribution of organic soil show that only about 2.2 % of farmlands are located on organic soil, including 1.0 % of cropland and 2.9 % of grassland; however, this study does not demonstrate, what are the driving forces of reduction of area of cropland on organic soil – if it is land use change or decomposition of organic layer driven phenomena[211].

Carbon stock change in living and dead woody biomass is based on activity data provided by the NFI. The biomass increment is used in calculations before 2009 and stock change method is applied for calculations in 2009-2014 assuming linear increment of carbon stock in cropland. Carbon stock in living and dead biomass is calculated using the same coefficients

[209] *L.U. Consulting, "Augšņu un reljefa izejas datu sagatavošana un eiropas komisijas izstrādāto augsnes un reljefa kritēriju mazā labvēlīgo apvidu noteikšanai piemērošanas simulācija (Projekta kopsavilkuma ziņojums)."*
[210]*Lazdiņš and Čugunovs, Oglekļa Dioksīda (CO?) Piesaistes Un Siltumnīcefekta Gāzu (SEG) Emisiju Un Zemes Lietojuma Veida Ietekmes Novērtējums Intensīvi Un Ekstensīvi Kultivētās Aramzemēs, Daudzgadīgos Zālājos Un Bioloģiski Vērtīgos Zālājos; Lazdiņš and Zariņš, Vēsturiskās (1990. Gada) Apsaimniekoto Aramzemju Platības Noteikšana Un Līdz 2009. Gadam Notikušo Aramzemju Platības Izmaiņu Novērtēšana.*
[211]*Lazdiņš et al., Atbalsts Klimata Pētījumu Programmai (Pārksats Par Projekta 2013. Gada Darba Uzdevumu Izpildi).*

as in calculations of carbon stock changes in forested land. All conversion factors for estimation of carbon in biomass are developed domestically[212].

Net carbon stock changes in mineral soil in cropland are reported as not occurring because no significant changes in management systems took place since 1990 and according to Tier 1 method of the 2006 IPCC Guidelines Chapter 5[213] the carbon stock changes in mineral soil should be reported in case of changes in management practice.

The assumptions used in EPIM tool for estimation of carbon stock change in living and dead biomass are shown in Table 6.23, default 20 years decay period is considered for dead wood.

**Table 6.23 Assumptions for calculation of carbon stock changes in living and dead biomass in cropland**

| Year | Cropland with woody vegetation, 1000 ha | Gross increment of living biomass | | Wood density, kg m$^{-3}$ | Natural mortality, m$^3$ ha$^{-1}$ | BEFs | | Carbon content, kg t$^{-1}$ |
|---|---|---|---|---|---|---|---|---|
| | | mill. M$^3$ | m$^3$ ha$^{-1}$ | | | stem to crown | stem to below-ground | |
| **1990** | 2.34 | 0.01 | 2.52 | 0.41 | 0.48 | 0.31 | 0.31 | 523 |
| **1991** | 2.34 | 0.01 | 2.52 | 0.41 | 0.48 | 0.31 | 0.31 | 523 |
| **1992** | 2.34 | 0.01 | 2.52 | 0.41 | 0.48 | 0.31 | 0.31 | 523 |
| **1993** | 2.34 | 0.01 | 2.52 | 0.41 | 0.48 | 0.31 | 0.31 | 523 |
| **1994** | 2.65 | 0.01 | 2.52 | 0.41 | 0.49 | 0.31 | 0.32 | 523 |
| **1995** | 2.65 | 0.01 | 2.52 | 0.41 | 0.49 | 0.31 | 0.32 | 523 |
| **1996** | 2.65 | 0.01 | 2.52 | 0.41 | 0.49 | 0.31 | 0.32 | 523 |
| **1997** | 2.65 | 0.01 | 2.52 | 0.41 | 0.49 | 0.31 | 0.32 | 523 |
| **1998** | 2.65 | 0.01 | 2.52 | 0.41 | 0.49 | 0.31 | 0.32 | 523 |
| **1999** | 2.65 | 0.01 | 2.52 | 0.41 | 0.5 | 0.32 | 0.32 | 523 |
| **2000** | 2.65 | 0.01 | 2.52 | 0.41 | 0.5 | 0.32 | 0.32 | 523 |
| **2001** | 2.65 | 0.01 | 2.52 | 0.41 | 0.5 | 0.32 | 0.32 | 523 |
| **2002** | 2.65 | 0.01 | 2.52 | 0.41 | 0.5 | 0.32 | 0.32 | 523 |
| **2003** | 2.65 | 0.01 | 2.52 | 0.41 | 0.5 | 0.32 | 0.32 | 523 |
| **2004** | 2.65 | 0.01 | 2.52 | 0.41 | 0.54 | 0.33 | 0.32 | 524 |
| **2005** | 2.65 | 0.01 | 2.52 | 0.41 | 0.54 | 0.33 | 0.32 | 524 |
| **2006** | 2.65 | 0.01 | 2.52 | 0.41 | 0.54 | 0.33 | 0.32 | 524 |
| **2007** | 1.45 | 0.01 | 6.19 | 0.41 | 1.34 | 0.33 | 0.32 | 524 |
| **2008** | 1.45 | 0.01 | 6.19 | 0.41 | 1.34 | 0.33 | 0.32 | 524 |
| **2009** | 1.45 | 0.01 | 6.19 | 0.41 | 1.42 | 0.33 | 0.32 | 524 |
| **2010** | 1.45 | 0.01 | 6.19 | 0.41 | 1.42 | 0.33 | 0.32 | 524 |
| **2011** | 1.45 | 0.01 | 6.19 | 0.41 | 1.42 | 0.33 | 0.32 | 524 |
| **2012** | 1.45 | 0.01 | 6.10 | 0.41 | 1.40 | 0.33 | 0.32 | 524 |
| **2013** | 1.46 | 0.01 | 6.19 | 0.41 | 1.82 | 0.33 | 0.32 | 524 |
| **2014** | 1.46 | 0.01 | 6.29 | 0.41 | 1.85 | 0.34 | 0.30 | 524 |

$CO_2$ emissions from drained organic soils in croplands were calculated using IPCC Wetlands Supplement Tier 1 method. Emission factor – 7.9 t C ha$^{-1}$ annually.

Drained organic soil in cropland is source of $CH_4$ emissions. $CH_4$ emissions are calculated by equation 2.6 in IPCC Wetlands Supplement. The emission factor for organic soils (Table 2.3 and table 2.4 in IPCC Wetlands Supplement) is 0±2.8 kg $CH_4$ ha$^{-1}$ yr$^{-1}$ (cropland, drained) and

[212] *Andis Lazdiņš et al., Mežsaimniecisko Darbību Ietekmes Uz Siltumnīcefekta Gāzu Emisijām Un $CO_2$ Piesaisti Novērtējums (pārskats Par 2013. Gada Darba Uzdevumu Izpildi) (Salaspils, 2013), Salaspils.*

[213] *Section 5.2.3.1 Choice of Method, Tier 1.*

emission factor for drainage ditches 1165±830 kg $CH_4$ $ha^{-1}$ $yr^{-1}$ (deep – drained cropland); respectively, only $CH_4$ emissions from ditches are calculated. Drainage systems on organic soils are considered. Area of ditches is considered equally proportional to area of drained organic soil in cropland. High resolution satellite images were used to estimate coverage of ditches in organic soils – 30 randomly selected drainage systems overlapping with former or current peat extraction sites (Figure 6.7) and obtained value (0.3 km $ha^{-1}$) was extrapolated to all organic soils.

**Figure 6.7 Sample area used to estimate area of ditches in organic soils**

### 6.5.2.2 Land converted to cropland (CRF 4.B.2)

Transition period for all land use changes is considered 20 years; respectively, land converted to cropland in 1990 is accounted under the cropland remaining cropland category in 2010. Land use changes to cropland in 1990-2008 are estimated using remote sensing based evaluation of vegetation index. The same data are used to identify extensively managed cropland, initially reported under grassland remaining grassland category.

Area of organic soil in land converted to cropland is calculated using different approach than in cropland remaining cropland. Instead of using proportion of area of organic soil in the final land use category, the values characteristic for initial land use are applied. Respectively, if share of organic soil in forest land remaining forest in 1990 is 22 %, it is considered, that area of organic soil in forest land converted to cropland in 1990 is 22 %[214.]

Unlike to cropland remaining cropland carbon stock change in living biomass in forest land converted to cropland is calculated as losses in living biomass due to felling of trees, considering average carbon stock in living biomass in forest land remaining forest in a particular year. Losses in dead wood are accounted similarly, as loss of average carbon stock in dead wood in a particular year. Carbon stock in litter is considered as constant value 12.14 ± 2.8 t C ha-1 according to the BioSoil project results in fertile stand types (*Hylocomiosa, Oxalidosa, Myrtilloso-sphagnosa, Myrtillosoi-polytrichosa, Myrtillosa mel.,*

[214] *Lazdiņš, Bārdule, and Stola, "Preliminary Results of Evaluation of Area of Organic Soils in Arable Lands in Latvia."*

*Mercurialosa mel.*). Instant oxidation method is applied to living biomass, dead wood and litter carbon pools.

Carbon stock changes in mineral soil are estimated using Equation 2.25 of the 2006 IPCC Guidelines. Impact factors for calculations of the carbon stock change under different management activities are taken from Table 5.5 in 2006 IPCC Guidelines:

- FLU 0.69 (Long-term cultivated, Temperate moist);
- FMG 1.00 (Full tillage, Temperate dry and wet);
- FI 1.00 (Medium input, all).

The initial carbon stock in mineral forest soil at 0-30 cm depth (reference C stock) is 82.6 ± 7.8 t $ha^{-1}$ according to the forest soil monitoring project BioSoil[215]. Forest stand types similar to agricultural lands are selected to calculate average carbon stock in forest soil (*Hylocomiosa, Oxalidosa, Myrtilloso-sphagnosa, Myrtillosoi-polytrichosa, Myrtillosa mel., Mercurialosa mel.*). Initial carbon stock at 0-30 cm depth in grassland is considered 77 ± 6.9 t $ha^{-1}$. The carbon stock in forest land converted to cropland after transition period of 20 years according to the Equation 2.25 is 57 t C $ha^{-1}$ at 0-30 cm depth; respectively, reduction of carbon stock in mineral soils is 25.6 t $ha^{-1}$ or 1.3 t C $ha^{-1}$ annually. The carbon stock in grassland converted to cropland after transition period of 20 years according to the Equation 2.25 is 52.7 t C $ha^{-1}$ at 0-30 cm depth; respectively, reduction of carbon stock in mineral soils is 23.7 t $ha^{-1}$ or 1.2 t C $ha^{-1}$ annually.

In organic soil of forest land and grassland converted to cropland the factor for cropland remaining cropland (7.9 t C $ha^{-1}$ annually) is used to estimate carbon stock changes.

The same approach as for cropland remaining cropland is used to calculate $CH_4$ emissions from drainage ditches.

### 6.5.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of area estimates is provided in Table 6.24.

**Table 6.24 Uncertainty of the cropland use data in 2014**

| Land use category | Number of NFI plots | Share of NFI plots, % | Uncertainty, % |
|---|---|---|---|
| **Cropland** | 4295 | 26.6 | 2.6 |
| **cropland remaining cropland** | 4255 | 26.3 | 2.6 |
| **organic soil** | 221 | 1.4 | 13.3 |
| **other soil** | 4034 | 25.0 | 2.7 |
| **land converted to cropland** | 40 | 0.3 | 53.4 |
| **organic soil** | 5 | 0.03 | 113.9 |
| **other soil** | 35 | 0.2 | 64.5 |

[215] *Lazdiņš et al., Mežsaimniecisko Darbību Ietekmes Uz Siltumnīcefekta Gāzu Emisijām Un $CO_2$ Piesaisti Novērtējums (pārskats Par 2013. Gada Darba Uzdevumu Izpildi).*

The uncertainty of $CO_2$ emission factor for organic soil is determined according to IPCC Wetlands Supplement. According to Table 5.5 of the 2006 IPCC Guidelines the uncertainty of impact factor for different management practices applied in croplands is 12 % for long term cultivating. No uncertainty is considered for full tillage and medium input (impact factor – 1). Uncertainty of $CH_4$ emission factor for drainage ditches is 71 % (Table 2.4 in IPCC Wetlands Supplement).

Uncertainty of average carbon stock in litter in forests is 23 %, uncertainty of carbon stock in mineral soil in forest land at 0-30 cm is 9 %, uncertainty of dead wood stock in forests is 2 %, uncertainty of carbon stock in dead wood according to the expert judgement is 30 %; the combined uncertainty of carbon stock in dead wood is 31 %.

Consistency of time series of calculations is secured by use of the NFI data for the cropland and grassland area and the NFI based remote sensing analysis for land use changes. The estimation of area of organic soil represents situation before 1990. Area of cropland on organic soil might be overestimated; however, more accurate data are expected in the Agricultural soil mapping project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy ", which will be completed in 2016.

### 6.5.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

The QA/QC plans for the cropland category includes the QC measures based on the IPCC (2006 IPCC Guidelines, Chapter 5.4.3, Tier 1 based QA/QC). The QA/QC procedures are implemented during every inventory. Several quality meetings are held annually between experts. Potential errors and inconsistencies are documented and corrections are made if necessary. Land use, as well as carbon stock in living and dead biomass related QA/QC procedures is implemented within the scope of the standard NFI procedure by re-measuring of 20 % of all sample plots. Training of the NFI field teams takes place every spring before starting the field works.

A part of remote sensing data (10 %) was evaluated manually during the remote analysis to estimate uncertainty of the automatic classification of vegetation index.

### 6.5.5 Category-specific recalculations

Recalculations are done due to recalculation of the NFI data based on repeated measurement of borders of the plots and their sectors. Summary of the impact of recalculation on the aggregated net GHG emissions from cropland is shown in Figure 6.8.

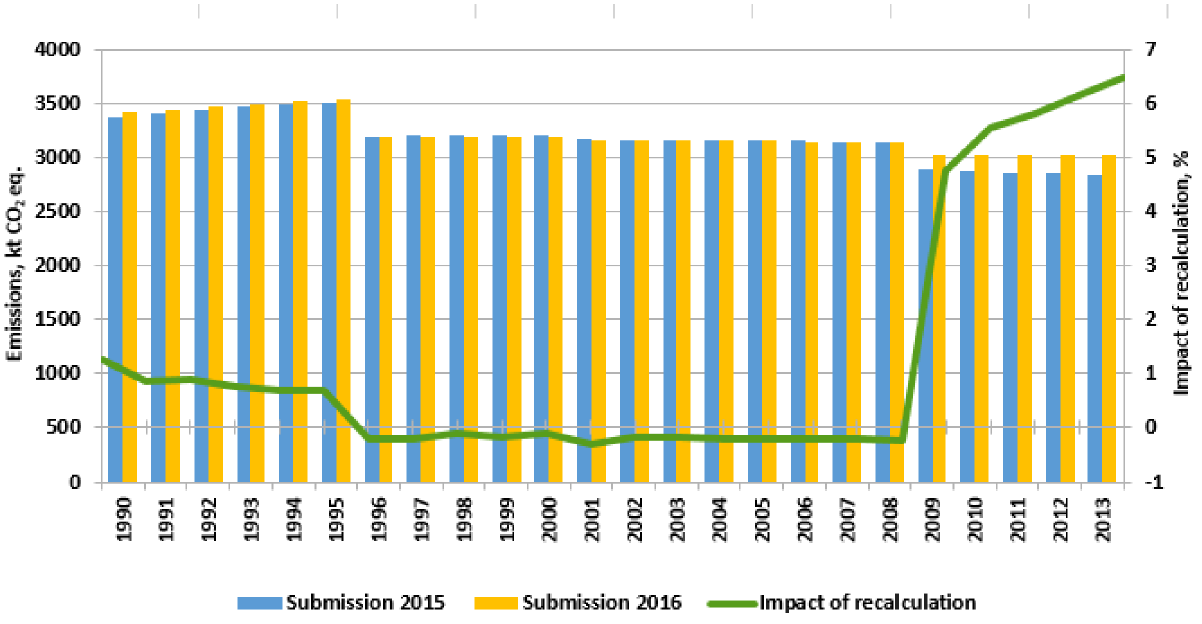


**Figure 6.8 Impact of recalculation on the aggregated net GHG emissions from cropland**

### 6.5.6 Category-specific planned improvements

There are several improvements proposed for the following inventories:

- updated area of organic soil in cropland according to the NFI study started in 2012[216]; the same values of share of organic soil will be used for land converted to cropland. Logarithmic regression will be used in time series to reduce share of organic soil in cropland before 1990 (5.18 %) to the actual value;
- updated $CO_2$ emissions from organic soil considering area changes and recent findings in Nordic and Baltic countries, particularly, doctoral thesis by Jüri-Ott Salm "Emission of greenhouse gases $CO_2$, $CH_4$, and $N_2O$ from Estonian transitional fens and ombrotrophic bogs: the impact of different land-use practice"[217].
- updated $N_2O$ emissions due to land use changes using emphyrical data on carbon stock changes in soil;
- Tier 1 methodology to estimate carbon stock changes in cropland considering changes of cropping practices since 1970.

Losses in living biomass, dead wood, litter and soil due to conversion of forest land to cropland are reported using Tier 1 approach, resulting in high emissions, which can lead to overestimation or underestimation of actual emissions, therefore Tier 2 approach will be developed. This activity is of special importance considering that the most of the land use conversions in projections of the processes in LULUCF sector relates to conversion of naturally afforested lands to cropland or grassland resulting in considerably smaller emissions than it is estimated according to Tier 1 approach.

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[216] *Lazdiņš, A., 2012. Atbalsts klimata pētījumu programmai (starpziņojums par 2012. gada darba uzdevumu izpildi) ( No. 020512/S68). LVMI Silava, Salaspils.*

[217] *Salm, J.O., 2012. Emission of greenhouse gases CO2, CH4, and N2O from Estonian transitional fens and ombrotrophic bogs: the impact of different land-use practice (Doctoral thesis). Tartu Ülikooli Kirjastus, Tartu.*

# 6.6 GRASSLAND (CRF 4.C)

## 6.6.1 Category description

The grassland's category is a key source of $CO_2$ emissions from soils. Total area of grassland in Latvia in 2014 was 737.23 kha, including 590.38 kha of grassland remaining grassland. Grassland remaining grassland is divided into mineral and organic soils. Area of the grassland is estimated using research data[218] on the base of remote sensing data analysis. The net emissions from grassland remaining grassland were 633.84 kt $CO_2$ eq. (including emissions from biomass burning) in Latvia in 2014 (Figure 6.9). The $CO_2$ removals are accounted in living and dead biomass in forest lands not fulfilling criteria of forest definition. The most of the emissions are associated with organic soils.

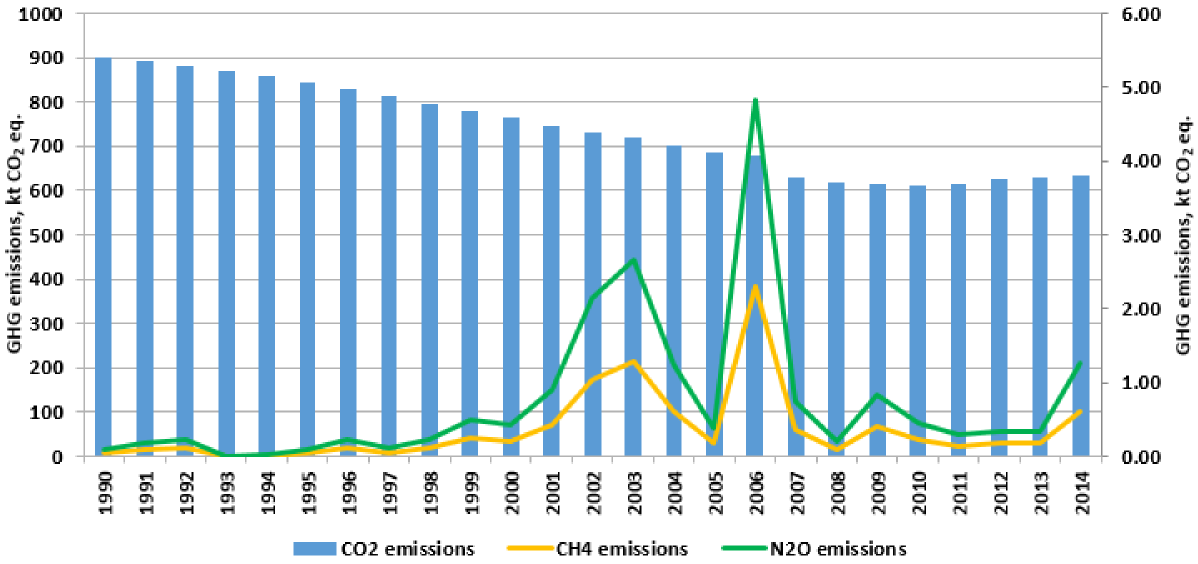


**Figure 6.9 Summary of GHG emissions from grassland remaining grassland[219] (kt $CO_2$ eq.)**

Land converted to cropland category is key source of $CO_2$ removals due to sequestration of carbon in mineral soil after conversion of cropland to grassland. Under this category all lands converted to grassland less than 20 years ago[220] are accounted and the total area is estimated to be 146.86 kha in 2014. Net GHG emissions in land category land converted to grassland excluding emissions from drained organic soil in 2014 were -219.86 kt $CO_2$ eq. (Figure 6.10). Increase of removals of $CO_2$ in land converted to grassland is associated with removals of $CO_2$ in soil due to land use change from cropland to grassland.

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[218] *Lazdiņš and Čugunovs, Oglekļa Dioksīda ($CO_2$) Piesaistes Un Siltumnīcefekta Gāzu (SEG) Emisiju Un Zemes Lietojuma Veida Ietekmes Novērtējums Intensīvi Un Ekstensīvi Kultivētās Aramzemēs, Daudzgadīgos Zālājos Un Bioloģiski Vērtīgos Zālājos.*

[219] *$CH_4$ and $N_2O$ emissions on secondary axis*

[220] *Lazdiņš and Zariņš, "Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol article 3.3 and 3.4 activities (Report on research work contracted by the Ministry of Environment of republic of Latvia)"; Lazdiņš, "Harmonization of Land Use Matrix in Latvia according to Requirements of International Greenhouse Gas Reporting System - Extending Outputs of National Forest Inventory Program"; Lazdiņš and Čugunovs, Oglekļa Dioksīda ($CO_2$) Piesaistes Un Siltumnīcefekta Gāzu (SEG) Emisiju Un Zemes Lietojuma Veida Ietekmes Novērtējums Intensīvi Un Ekstensīvi Kultivētās Aramzemēs, Daudzgadīgos Zālājos Un Bioloģiski Vērtīgos Zālājos.*

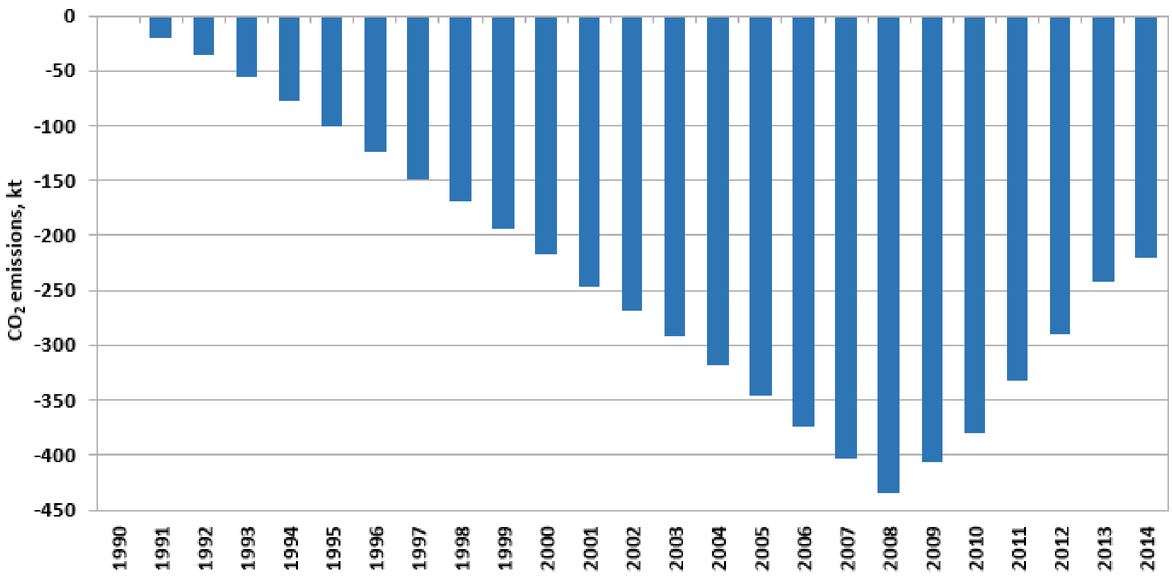


**Figure 6.10 Summary of $CO_2$ emissions in land converted to grassland (kt)**

Grassland remaining grassland is divided into mineral (95% of total area of grassland remaining grassland) and organic (5% of total area of grassland remaining grassland) soils. It is assumed that mineral soils are neither a source nor sink of $CO_2$. It could be changed depending on management level (degraded or improved) in grasslands; however, according to the expert judgement the inventory team considered that all grasslands are managed in way that there are no degraded or improved grasslands. The judgement is based on the fact that husbandry production in Latvia decreased considerably since 1990, but area of pastures and grasslands is increased. This fact demonstrates extensive use of former pastures and lands used in fodder production before 1990. This type of management systems is not associated with decrease of carbon stock in soil. Organic soils are considerable source of $CO_2$ emissions. Organic soils and drainage ditches in grasslands are accounted as a source of methane also as it is recommended in IPCC Wetlands Supplement Chapter 2.

All categories of land use change to grassland, except cropland to grassland, are reported as NO, because there are no evidences of such conversions. Conversion from cropland to grassland takes place due to abandonment of cropland. Grassland is reported in the managed lands category.

Increase of the area of organic soils in the land converted to cropland category is associated with conversion of cropland to grassland during the 1990s and during the last decade. Opposite process – reduction of area of grassland – took place due to afforestation (both natural expansion of forest and planting) of farmlands.

## 6.6.2 Methodological issues

### 6.6.2.1 Grassland remaining grassland (CRF 4.C.1)

Area of the grassland is estimated using research data[221] on the base of remote sensing data analysis. Information about area of organic agricultural soils is provided by the research report (5.18 % ± 11 % of total area of farmlands)[222]. These figures are based on soil mapping data and characterizes situation before 1990 (data utilized in calculation were obtained from the 60[ths] to early 80[ths]).

Woody biomass increment figures for 2004-2014 are taken from the NFI, but for the historical data results of recalculation of increment of living biomass in grassland are considered[223]. Mortality factors are taken directly from forest land remaining forest assuming that mortality in grassland is equal to average mortality (in percent of increment of living biomass) in forest land in a particular year. Decay period for dead wood is considered 20 years according to 2006 IPCC Guidelines.

The assumptions for biomass calculations used in EPIM tool are shown in Table 6.25 default 20 years decay period is considered for dead wood.

**Table 6.25 Relative stock changes for grassland management in mineral soils**

| Factor | Level | Climate regime | IPCC default | Uncertainty |
|---|---|---|---|---|
| **Land use** | All | All | 1.0 | NA |
| **Management** | Nominally managed (non-degraded) | All | 1.0 | NA |
| **Management** | Moderately degraded grassland | Temperate / Boreal | 0.95 | ± 13% |
| **Management** | Severely degraded | All | 0.7 | ± 40% |
| **Management** | Improved grassland | Temperate / Boreal | 1.14 | ± 11% |
| **Input (applied only to improved grassland)** | Medium | All | 1.0 | NA |
| **Input (applied only to improved grassland)** | High | All | 1.11 | ± 7% |

The calculations are done in EPIM tool, which is still in development stage. The assumptions used in EPIM tool are shown in Table 6.26, default 20 years decay period is considered for dead wood.

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[221]*Lazdiņš and Čugunovs, Oglekļa Dioksīda ($CO_2$) Piesaistes Un Siltumnīcefekta Gāzu (SEG) Emisiju Un Zemes Lietojuma Veida Ietekmes Novērtējums Intensīvi Un Ekstensīvi Kultivētās Aramzemēs, Daudzgadīgos Zālājos Un Bioloģiski Vērtīgos Zālājos.*
[222]*L.U. Consulting, "Augšņu un reljefa izejas datu sagatavošana un eiropas komisijas izstrādāto augsnes un reljefa kritēriju mazā labvēlīgo apvidu noteikšanai piemērošanas simulācija (Projekta kopsavilkuma ziņojums)."*
[223] *Jansons, Methods Utilized to Recalculate Historical Forest Increment Data.*

**Table 6.26 Assumptions for calculation of carbon stock changes in living and dead biomass in grassland**

| Year | Grassland with woody vegetation, 1000 ha | Gross increment of living biomass | | Wood density, kg m⁻³ | Natural mortality, m³ ha⁻¹ | BEFs | | Carbon content, kg t⁻¹ |
|---|---|---|---|---|---|---|---|---|
| | | mill. M³ | m³ ha⁻¹ | | | stem to crown | stem to below-ground | |
| **1990** | 19.13 | 0.02 | 0.97 | 0.41 | 0.18 | 0.31 | 0.31 | 523 |
| **1991** | 19.44 | 0.02 | 0.95 | 0.41 | 0.18 | 0.31 | 0.31 | 523 |
| **1992** | 19.75 | 0.02 | 1 | 0.41 | 0.19 | 0.31 | 0.31 | 523 |
| **1993** | 20.07 | 0.02 | 0.99 | 0.41 | 0.19 | 0.31 | 0.31 | 523 |
| **1994** | 20.38 | 0.02 | 0.99 | 0.41 | 0.19 | 0.31 | 0.32 | 523 |
| **1995** | 20.69 | 0.02 | 0.97 | 0.41 | 0.19 | 0.31 | 0.32 | 523 |
| **1996** | 21.00 | 0.02 | 0.96 | 0.41 | 0.19 | 0.31 | 0.32 | 523 |
| **1997** | 21.32 | 0.02 | 0.96 | 0.41 | 0.19 | 0.31 | 0.32 | 523 |
| **1998** | 21.63 | 0.02 | 0.94 | 0.41 | 0.19 | 0.31 | 0.32 | 523 |
| **1999** | 21.94 | 0.02 | 0.98 | 0.41 | 0.2 | 0.32 | 0.32 | 523 |
| **2000** | 22.26 | 0.02 | 0.97 | 0.41 | 0.19 | 0.32 | 0.32 | 523 |
| **2001** | 22.57 | 0.02 | 0.96 | 0.41 | 0.19 | 0.32 | 0.32 | 523 |
| **2002** | 22.88 | 0.02 | 0.94 | 0.41 | 0.19 | 0.32 | 0.32 | 523 |
| **2003** | 23.19 | 0.02 | 0.93 | 0.41 | 0.19 | 0.32 | 0.32 | 523 |
| **2004** | 23.51 | 0.02 | 0.92 | 0.41 | 0.2 | 0.33 | 0.32 | 524 |
| **2005** | 23.82 | 0.02 | 0.91 | 0.41 | 0.2 | 0.33 | 0.32 | 524 |
| **2006** | 24.13 | 0.02 | 0.89 | 0.41 | 0.19 | 0.33 | 0.32 | 524 |
| **2007** | 23.54 | 0.05 | 2.12 | 0.41 | 0.46 | 0.33 | 0.32 | 524 |
| **2008** | 23.54 | 0.05 | 2.12 | 0.41 | 0.46 | 0.33 | 0.32 | 524 |
| **2009** | 23.54 | 0.05 | 2.12 | 0.41 | 0.49 | 0.33 | 0.32 | 524 |
| **2010** | 23.54 | 0.05 | 2.12 | 0.41 | 0.49 | 0.33 | 0.32 | 524 |
| **2011** | 23.54 | 0.05 | 2.12 | 0.41 | 0.49 | 0.33 | 0.32 | 524 |
| **2012** | 23.62 | 0.04 | 1.88 | 0.41 | 0.43 | 0.33 | 0.32 | 524 |
| **2013** | 23.76 | 0.05 | 1.93 | 0.41 | 0.57 | 0.33 | 0.32 | 524 |
| **2014** | 23.95 | 0.05 | 1.98 | 0.41 | 0.58 | 0.34 | 0.30 | 524 |

The emission factor of drained organic soils is considered to be 6.1 t C ha$^{-1}$ yearly according to IPCC KP Supplement.

Emission factors for $CH_4$ emissions from drained organic soil and drainage ditches are respectively 16 kg and 1165 kg $CH_4$ yearly according to Tables 2.3 and 2.4 in IPCC KP Supplement. Total area of drainage ditches is estimated by using the same approach as explained in cropland. Ditch density on organic soils is assumed to be 0.045 ha ha$^{-1}$.

Default coefficients on impact of different management regime on carbon emissions obtained from 2006 IPCC Guidelines Chapter 6, Table 6.2 are used to calculate carbon stock changes in mineral soil (Table 6.27). Combined impact factor for carbon stock changes in mineral soil is equal to 1 (land use – all, management – non-degraded, input – medium).

**Table 6.27 Relative stock changes due to grassland management on mineral soils**

| Factor | Level | Climate regime | IPCC default | Uncertainty |
|---|---|---|---|---|
| **Land use** | All | All | 1.0 | NA |
| **Management** | Nominally managed (non-degraded) | All | 1.0 | NA |
| **Management** | Moderately degraded grassland | Temperate / Boreal | 0.95 | ± 13% |

| Factor | Level | Climate regime | IPCC default | Uncertainty |
|---|---|---|---|---|
| **Management** | Severely degraded | All | 0.7 | ± 40% |
| **Management** | Improved grassland | Temperate / Boreal | 1.14 | ± 11% |
| **Input (applied only to improved grassland)** | Medium | All | 1.0 | NA |
| **Input (applied only to improved grassland)** | High | All | 1.11 | ± 7% |

$N_2O$ and $CH_4$ emissions from biomass burning are calculated according to methodology described in following chapter on Biomass burning.

#### 6.6.2.2 Land converted to grassland (CRF 4.C.2)

Carbon stock changes in mineral soils in cropland converted to grassland are reported as net removals, because there are research evidences, that carbon stock in grasslands in average at 0-30 cm depth is significantly higher than in cropland[224] and the difference is 23.7 t C $ha^{-1.}$ These data are based on comparison of 80 NFI sample plots and will be updated in future by continuous monitoring of carbon stock change in soil.

Methane emissions from ditches on organic soils have been included in estimates also for lands converted to grasslands and it is calculated with the same approach as grassland remaining grassland.

### 6.6.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of area estimates is provided in Table 6.28.

**Table 6.28 Uncertainty of the grassland use data in 2014**

| Land use category | Number of NFI plots | Share of NFI plots, % | Uncertainty, % |
|---|---|---|---|
| **Grassland** | 1747 | 10.8 | 4.2 |
| **grassland remaining grassland** | 1407 | 8.7 | 5.0 |
| **organic soil** | 73 | 0.5 | 25.7 |
| **other soil** | 1334 | 8.3 | 5.1 |
| **land converted to grassland** | 340 | 2.1 | 9.8 |
| **organic soil** | 17 | 0.1 | 55.1 |
| **other soil** | 324 | 2.0 | 10.0 |

The uncertainty estimate for the $CO_2$ emission factor for organic soils is 19 % according to the Table 2.1 in IPCC Wetlands Supplement.

Uncertainties for emission factors used in calculation of $CH_4$ emissions from organic grasslands and drainage ditches are 83 % and 71 % according to Table 2.3 and Table 2.4 in IPCC Wetlands Supplement.

[224] *Lazdiņš, Bārdule, and Stola, "Preliminary Results of Evaluation of Carbon Stock in Historical Cropland and Grassland"; Lazdiņš et al., Atbalsts Klimata Pētījumu Programmai (Pārksats Par Projekta 2013. Gada Darba Uzdevumu Izpildi).*

The time series of emissions from grasslands is consistent; however, overestimation is possible due to lack of knowledge about current area and distribution of organic soils. Recent studies shows that area of organic soils in grassland is less than 1.5 %[225].

### 6.6.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

The QA/QC plans for the Grassland's category includes the QC measures based on the IPCC (2006 IPCC Guidelines, Chapter 6.4.3, Tier 1 approach). These measures are implemented every year during the inventory. Potential errors and inconsistencies are documented and corrections are made if necessary. The files and documents used in preparation of the inventory are archived annually and back-up copies are made weekly. Several quality meetings are held annually between experts.

### 6.6.5 Category-specific recalculations

Recalculations are done due to recalculation of the NFI data based on repeated measurement of borders of the plots and their sectors. Summary of the impact of recalculation on the aggregated net GHG emissions from grassland is shown in Figure 6.11.

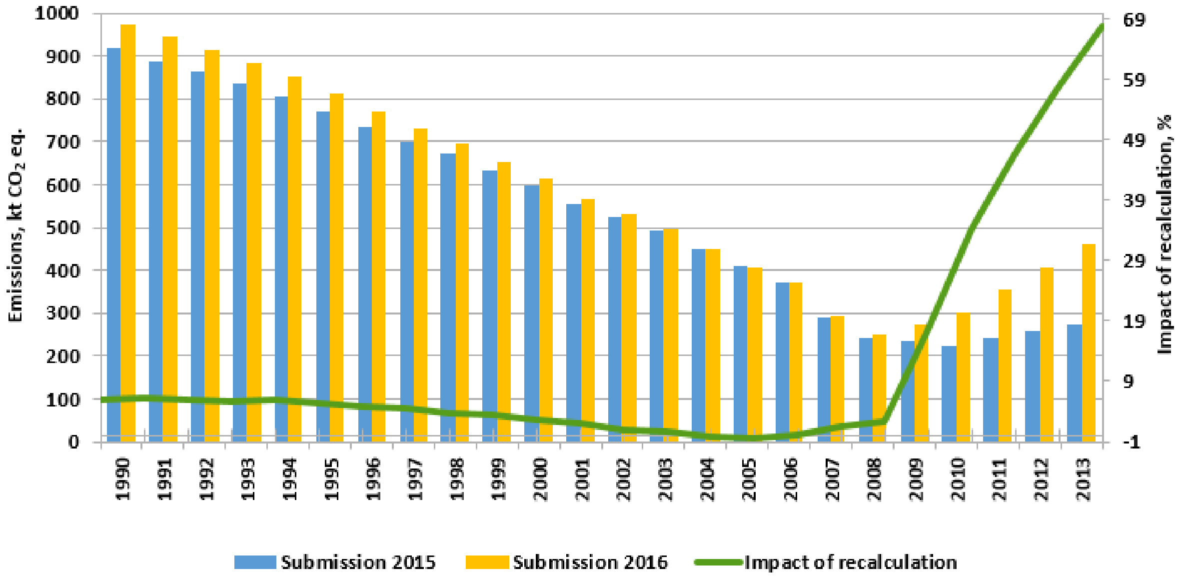


**Figure 6.11 Impact of recalculation on the aggregated net GHG emissions from grassland**

### 6.6.6 Category-specific planned improvements

It is planned to improve accounting for ditch area in organic soil in next years. Now we have very limited knowledge about organic soils and drainage ditches in grasslands. In 2016 new

[225] *Andis Lazdiņš et al., Atbalsts Klimata Pētījumu Programmai (Pārksats Par Projekta 2013. Gada Darba Uzdevumu Izpildi) (Salaspils, 2013), Salaspils; Andis Lazdiņš, Atbalsts Klimata Pētījumu Programmai (starpziņojums Par 2012. Gada Darba Uzdevumu Izpildi) (Salaspils, 2012), Salaspils, https://sites.google.com/site/lvlulucf/research-projects/atbalstsklimatapetijumuprogrammaistarpzinojumspar2012gadarezultatiem.*

NFI inventory data and results about organic soils in grassland will be available and on the basis of the NFI inventory it will be possible to specify accounting.

Country specific data are necessary to estimate carbon stock changes according to the soil mapping data, as well as to estimate share of organic soil in land converted to grassland.

## *6.7 WETLANDS (CRF 4.D)*

### 6.7.1 Category description

Wetlands remaining wetlands is a key source category of $CO_2$ emissions mainly due to commercial peat extraction for horticulture and emissions of $CO_2$ from drained soil. The net GHG emissions in wetlands in 2014 were 1014.57 kt $CO_2$ eq (Figure 6.12).

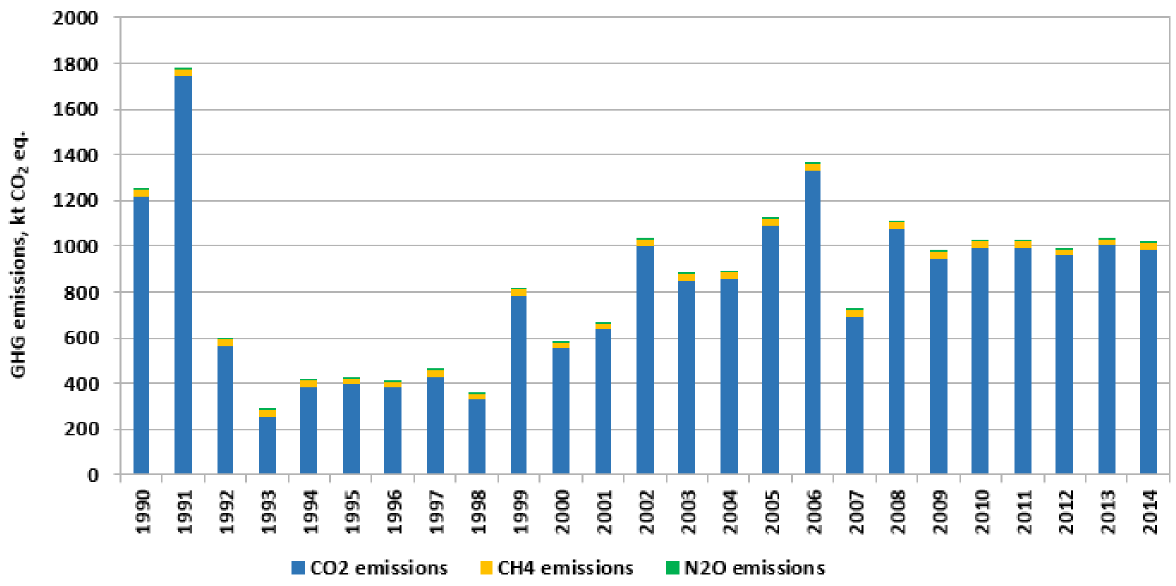


**Figure 6.12 Summary of GHG emissions from wetlands (kt $CO_2$ eq.)**

According to the 2006 IPCC Guidelines wetlands include land that is covered or saturated by water for all or part of the year and that does not fall into the forest land, cropland, and grassland or settlement categories. Total area of wetlands (445.63 kha) is reported according to the research results, including 27.0 kha of peat-lands drained for peat extraction (Table 3a.3.3 of the IPCC GPG LULUCF 2003).

Latvia reports $CO_2$ emissions associated mainly with industrial peat extraction in this category. The rest of the area of wetlands is not managed and $CO_2$ emissions are not calculated, exception is area with woody vegetation located adjacent to water courses, water body or swamps and which does not fit to definition of forest land category. According to the Table 3a.3.3 of the IPCC GPG LULUCF 2003 the default value for area of industrial peat-lands in Latvia is 27 kha; using extraction rate method calculations result in 3 kha in 2014. Taking into account considerable annual fluctuations in peat production, more conservative default method is used in calculations.

Aggregated emissions from industrial peat-lands are equal for the whole time series due to lack of data about status of industrial peat-lands prepared for extraction 20-40 years ago. However, there are no evidences of new industrial peat-lands prepared for peat extraction after 1990; therefore, the risk of underestimation of emissions does not exist. $N_2O$ contributes to about 0.4 % of net emissions from peat-lands. Removals in this category are reported in living and dead biomass.

### 6.7.2 Methodological issues

Activity data – area of peat-lands prepared for extraction, is taken from Table 3a.3.3[226] of the IPCC GPG LULUCF 2003. Emission factor for carbon stock changes (2.8 t C $ha^{-1}$ $yr^{-1}$) due to drainage is taken from IPCC Wetlands Supplement[227]. Carbon content in air dry peat (0.45 t C per tonne of peat) is considered according to Table 7.5 of 2006 IPCC Guidelines[228]. Moisture of peat reported in national statistics is considered 40 %.

Off-site $CO_2$-C emissions associated to the horticultural (non-energy) use of peat extracted and removed are reported using instant oxidation method. Off-site emissions from peat used for energy are reported in the Energy Sector (1.A.1. Energy industries, 1.A.2. Manufacturing industries and construction and 1.A.4. Other sectors), and is therefore not included here.

Data on peat extraction for horticulture purposes is taken from statistical reports using extrapolation method for the periods, when official data are not available. Carbon content in peat is considered 54 %, relative moisture – 40 %, according to a methodology used in statistical accounting.

$CH_4$ emissions from drained organic soils are calculated according to methodology applied in drained forests on organic soil. As drainage of wetlands in national conditions is occurring only in territories for peat extraction default emission factors for drained organic soil (6.1 kg $CH_4$ $ha^{-1}$ $yr^{-1}$) and drainage ditches (542 kg $CH_4$ $ha^{-1}$ $yr^{-1}$) for peat extraction are utilized. Density of ditches is considered 0.07 ha per 1 ha of peatland.

The calculations are done in EPIM tool, which is still in development stage. The assumptions used in EPIM tool are shown in Table 6.29, default 20 years decay period is considered for dead wood.

**Table 6.29 Assumptions for calculation of carbon stock changes in living and dead biomass in wetlands**

| Year | Wetlands with woody vegetation, 1000 ha | Gross increment of living biomass | | Wood density, kg $m^{-3}$ | Natural mortality, $m^3$ $ha^{-1}$ | BEFs | | Carbon content, kg $tonne^{-1}$ |
|---|---|---|---|---|---|---|---|---|
| | | mill. $M^3$ | $m^3$ $ha^{-1}$ | | | stem to crown | stem to below-ground | |
| **1990** | 189.25 | 0.06 | 0.33 | 0.41 | 0.06 | 0.31 | 0.31 | 523 |
| **1991** | 191.55 | 0.07 | 0.37 | 0.41 | 0.07 | 0.31 | 0.31 | 523 |
| **1992** | 193.42 | 0.08 | 0.41 | 0.41 | 0.08 | 0.31 | 0.31 | 523 |
| **1993** | 194.24 | 0.08 | 0.42 | 0.41 | 0.08 | 0.31 | 0.31 | 523 |
| **1994** | 195.72 | 0.09 | 0.44 | 0.41 | 0.09 | 0.31 | 0.32 | 523 |
| **1995** | 196.29 | 0.09 | 0.45 | 0.41 | 0.09 | 0.31 | 0.32 | 523 |
| **1996** | 197.92 | 0.09 | 0.46 | 0.41 | 0.09 | 0.31 | 0.32 | 523 |

[226] *Estimates of peatland areas and use for tier 1 in 1000 hectares*
[227] *EMISSION FACTORS FOR CO2–C AND ASSOCIATED UNCERTAINTY FOR LANDS MANAGED FOR PEAT EXTRACTION, BY CLIMATE ZONE*
[228] *CONVERSION FACTORS FOR CO2–C FOR VOLUME AND WEIGHT PRODUCTION DATA*

| Year | Wetlands with woody vegetation, 1000 ha | Gross increment of living biomass | | Wood density, kg m⁻³ | Natural mortality, m³ ha⁻¹ | BEFs | | Carbon content, kg tonne⁻¹ |
|---|---|---|---|---|---|---|---|---|
| | | mill. M³ | m³ ha⁻¹ | | | stem to crown | stem to below-ground | |
| **1997** | 199.26 | 0.09 | 0.46 | 0.41 | 0.09 | 0.31 | 0.32 | 523 |
| **1998** | 201.05 | 0.09 | 0.47 | 0.41 | 0.09 | 0.31 | 0.32 | 523 |
| **1999** | 201.2 | 0.09 | 0.47 | 0.41 | 0.09 | 0.32 | 0.32 | 523 |
| **2000** | 202.54 | 0.1 | 0.47 | 0.41 | 0.09 | 0.32 | 0.32 | 523 |
| **2001** | 203.12 | 0.1 | 0.47 | 0.41 | 0.09 | 0.32 | 0.32 | 523 |
| **2002** | 204.27 | 0.1 | 0.47 | 0.41 | 0.09 | 0.32 | 0.32 | 523 |
| **2003** | 205.96 | 0.1 | 0.47 | 0.41 | 0.09 | 0.32 | 0.32 | 523 |
| **2004** | 206.59 | 0.1 | 0.46 | 0.41 | 0.1 | 0.33 | 0.32 | 524 |
| **2005** | 206.71 | 0.1 | 0.46 | 0.41 | 0.1 | 0.33 | 0.32 | 524 |
| **2006** | 210.16 | 0.1 | 0.46 | 0.41 | 0.1 | 0.33 | 0.32 | 524 |
| **2007** | 97.62 | 0.18 | 1.85 | 0.41 | 0.4 | 0.33 | 0.32 | 524 |
| **2008** | 97.62 | 0.18 | 1.85 | 0.41 | 0.4 | 0.33 | 0.32 | 524 |
| **2009** | 97.62 | 0.18 | 1.85 | 0.41 | 0.43 | 0.33 | 0.32 | 524 |
| **2010** | 97.62 | 0.18 | 1.85 | 0.41 | 0.43 | 0.33 | 0.32 | 524 |
| **2011** | 97.62 | 0.18 | 1.85 | 0.41 | 0.43 | 0.33 | 0.32 | 524 |
| **2012** | 97.62 | 0.17 | 1.73 | 0.41 | 0.40 | 0.33 | 0.32 | 524 |
| **2013** | 97.62 | 0.17 | 1.79 | 0.41 | 0.53 | 0.33 | 0.32 | 524 |
| **2014** | 97.62 | 0.18 | 1.84 | 0.41 | 0.54 | 0.34 | 0.30 | 524 |

### 6.7.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of area estimates is provided in Table 6.30.

**Table 6.30 Uncertainty of the wetland use data in 2014**

| Land use category | Number of NFI plots | Share of NFI plots, % | Uncertainty, % |
|---|---|---|---|
| **Wetlands** | 1123 | 7.0 | 5.7 |
| **wetlands remaining wetlands** | 1119 | 6.9 | 5.9 |
| **drained soil** | 68 | 0.4 | 24.2 |
| **wet soil** | 1051 | 6.5 | 6.1 |
| **land converted to wetlands** | 4 | 0.03 | 13.4 |

The uncertainty estimate for the $CO_2$ emission factor for organic soils is 55 % according to the Table 2.1 in IPCC Wetlands Supplement.

Uncertainty range of emission factors for drained organic soil and drainage ditches are 1.6-11 kg $CH_4$ $ha^{-1}$ $yr^{-1}$ (77%) and 102-981 kg $CH_4$ $ha^{-1}$ $yr^{-1}$ (81%) according to the Table 2.3 and Table 2.4 in IPCC Wetlands Supplement.

Complete consistency of the time-series is secured by use of the same data source for estimation of area and emissions for the whole time period. Emissions associated with peat extraction might be considerably overestimated because this industry is reduced during last decades and area of peat-lands prepared for extraction is reduced too. However, there are no statistically verifiable data about technical status of peat quarries therefore default values of activity data based on situation before 1990 are used in calculations.

### 6.7.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

Quality control procedures named in 2006 IPCC Guidelines were done, particularly, data about peat extraction were compiled from different sources (national statistics and Union of peat producers) as well as emission factors provided by different authors were compared. Several quality meetings are held annually between experts.

### 6.7.5 Category-specific recalculations

No recalculations are done in this sector.

### 6.7.6 Category-specific planned improvements

Non-$CO_2$ GHG might be considerable part of emissions from wetlands; therefore, it is necessary to develop method for estimation impact of ditches and other types of wetlands on $N_2O$ and $CH_4$ emissions. Considering growth potential of peat extraction for energy purposes from abandoned peat-lands and forests on wet organic soils, it is important to be able to calculate impact of drainage on non-$CO_2$ emissions as well as to be able to separate wetlands on nutrients rich organic soils (high $N_2O$ emissions) and poor organic soils (low $N_2O$ emissions). Wetlands are one of the priorities in further development of GHG inventory in LULUCF sector in Latvia.

## *6.8 SETTLEMENTS (CRF 4.E)*

### 6.8.1 Category description

Net $CO_2$ emissions from settlements remaining settlements in 2014 were -95.28 kt $CO_2$ (Figure 6.13). However, removals in woody vegetation and dead biomass in settlements remaining settlements were compensated by emissions due to land use change (land converted to settlements category). Net $CO_2$ emissions from land converted to settlements in 2014 were 992.36 kt $CO_2$ (Figure 6.14).

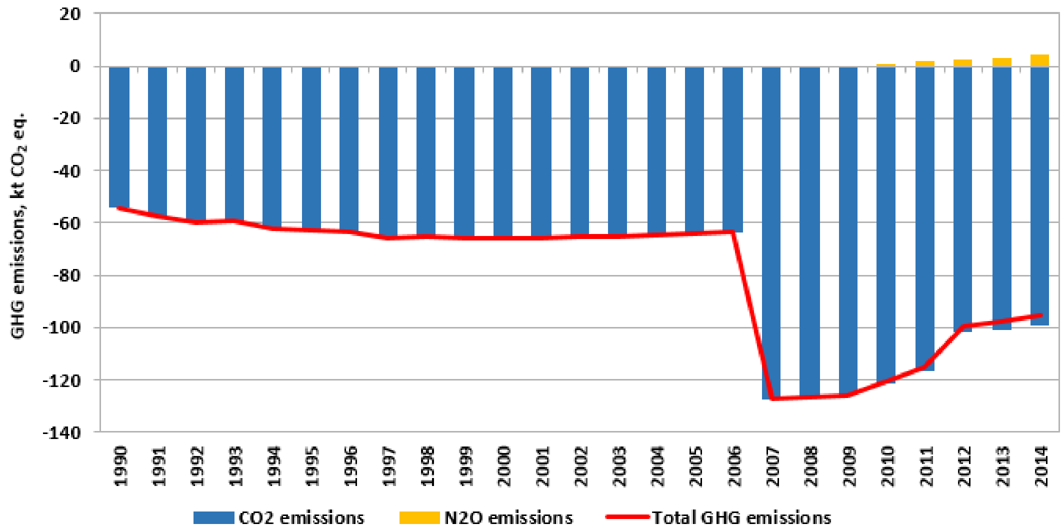


**Figure 6.13 Summary of net GHG emissions from settlements remaining settlements (kt $CO_2$ eq.)**

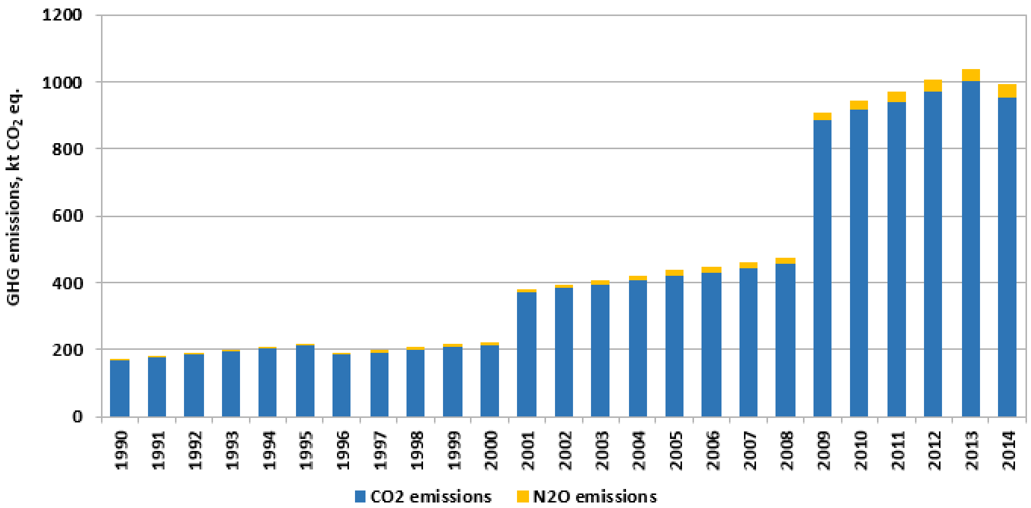


**Figure 6.14 Summary of net GHG emissions from land converted to settlements (kt $CO_2$ eq.)**

Land converted to settlements is a key source of $CO_2$ emissions according to trend and level assessment due to losses in carbon stock in living biomass, dead wood, litter and soil carbon pool. The role of conversion of forest land to settlements is increasing with a growth of economic activity and road construction in rural regions, because more than half of the country area is covered by forests, so that any new constructions are always associated with conversion of forest lands. At the same time abandoned farmlands conversion to forest land is more intensive; however, young forests on farmlands can not fully compensate emissions due to the forest lands conversion to settlements.

Under the settlements category emissions from soils, litter, living and dead biomass due to conversion of land use type are reported. In 2014 removals in living and dead biomass in settlements are accounted using the NFI data on increment of growing stock in settlements, which is represented mostly by overgrowing of roadsides, power lines and other infrastructure.

Total area of settlements in 2014 was 253.73 kha, including 215.28 kha of settlements remaining settlements since 1990. The total area of settlements is estimated according to the information provided by the NFI. According to the expert estimation, increase of area of settlements during last 20 years occurred due to conversion of forest land. Increase of area of settlements (deforestation) is generally associated with road construction. All roads, including forest roads are reported in the settlements category; therefore, the deforested area is considerably higher than official statistics, where forest roads are not accounted as deforested area and still belong to forest land.

## 6.8.2 Methodological issues

### 6.8.2.1 Settlements remaining settlements (CRF 4.E.1)

Area of land remaining settlements is assumed constant until 2008 (238.23 kha) according to the NFI data. In 2010-2014 areas converted to settlements in 1990-1994 are accounted under settlements remaining settlements.

The $CO_2$ removals are accounted for living and dead biomass categories in settlements remaining settlements based on the NFI data. Removals are accounted based on weighted (by area) gross increment, mortality factors, BEFs, carbon content and wood density in a particular year in forest land remaining forest. For emissions from dead wood pool in settlements remaining settlements 20 years transition period is considered. Age of woody vegetation on settlements is counted backwards and as soon as age of trees reach "0", it is considered, that there is no more vegetation and no increment calculations are done. EPIM tool is used in calculations.

Emissions from soils in settlements remaining settlements are calculated according 2006 IPCC Guidelines. It is assumed that inputs equal outputs so that settlement mineral soil C stocks do not change in settlements remaining settlements. Emissions from organic soils in settlements remaining settlements are calculated using equation 2.26 in 2006 IPCC Guidelines (equation No. 6). If soils are drained and the peat is not removed, the emissions are calculated using emission factors for cultivated organic soils, due to deep drainage in settlements similar to cropland. Annual emission factor (EF) for cultivated organic soils in cool temperate climatic temperature regime is 5.0 tonnes C $ha^{-1}$ $yr^{-1}$ (2006 IPCC Guidelines, Table 5.6).

$$L_{Organic} = \sum_c (A \cdot EF)_c \text{, where}$$

$L_{Organic}$ = annual carbon loss from drained organic soils, tonnes C $yr^{-1}$;
A = land area of drained organic soils in climate type c, ha;
EF = emission factor for climate type c, tonnes C $ha^{-1} yr^{-1}$. (6)

### 6.8.2.2 Land converted to settlements (CRF 4.E.2)

Area of land converted to settlements is estimated by evaluation of vegetation index of the NFI points (23 thousand plots across the country) in series of satellite images produced in 1990, 1995 and 2000. Final land use was considered according to empiric data obtained during field visits (2009-2013). Points, where the vegetation index permanently changed from forest to non-forest land were marked as potentially deforested. Then logical selection was used to separate those points where removal of woody vegetation is not associated with land use change (for instance, cleaning of roadsides outside forest lands and buffer zones of railways) or changes in vegetation index were not permanent (for instance, forest in

1990, non-forest in 1995, forest in 2000 and settlement with woody vegetation in 2004-2008 according to the NFI), and the rest of points, mostly forest roads, were noted as deforested.

Linear regression based on remote sensing data was used to elaborate prognosis for conversion of forest land to other land uses in 2004-2008. NFI data are used to estimate land converted to settlements in 2009-2014.

Area of land converted to settlement since 1990 is estimated using satellite image analysis. Total area of land converted to settlements in 2014 is 38.45 kha.

The emissions (losses in carbon pools) are reported under category forest land converted to settlements. Carbon stock changes associated with commercial felling, including removal of woody vegetation on forest infrastructure (roadsides, ditches etc.) are accounted considering that losses in living biomass are equal to average growing stock in forest land remaining forest in a particular year. Similarly, dead wood stock in forest land remaining forest in a particular year is considered as carbon losses from dead wood due to conversion of forest land to settlements. Instant oxidation method is considered for living and dead wood carbon pools.

Carbon stock changes in dead biomass are accounted using instant oxidation method considering that all dead biomass converts to emissions in the year of the land use change. Average carbon stock in dead biomass (12.14 t C $ha^{-1}$ in litter and 6.0 t C $ha^{-1}$ in dead wood) is used in calculations. Carbon stock in dead wood in converted land is considered to be equal to average carbon stock in dead biomass in forest land remaining forest land in a year of the conversion.

Losses due to commercial felling in forest areas converted to settlements are accounted considering that the losses are equal to average growing stock of living biomass in forest land remaining forest in the year of conversion (BEFs, carbon content and wood density are considered as weighted (Figure 6.15) by total biomass distribution between species).

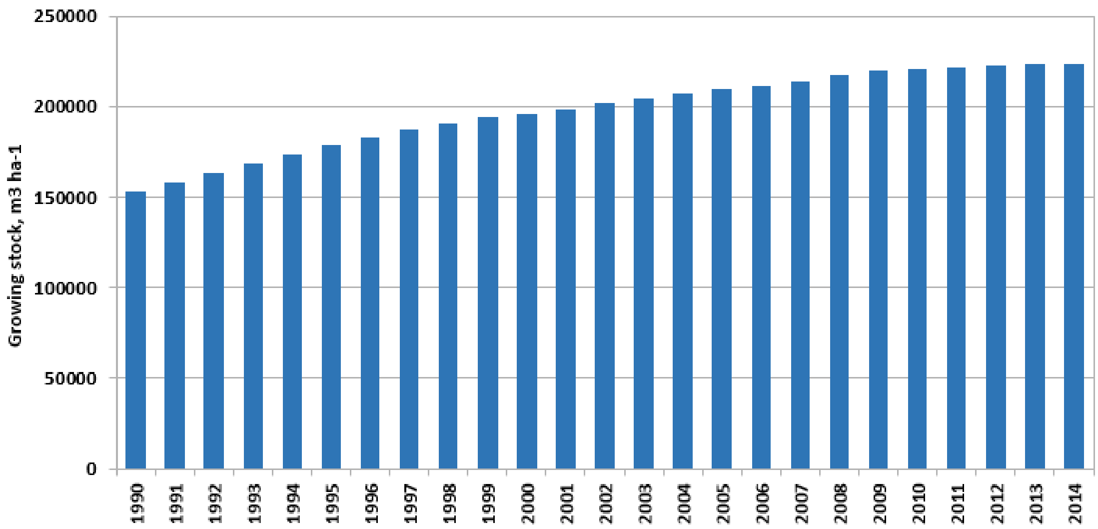


**Figure 6.15 Assumption for average growing stock of living biomass in forest areas converted to settlements ($m^3$ $ha^{-1}$)**

The total change in soil C stocks for land converted to settlements is computed using equation 2.24 in 2006 IPCC Guidelines, which combines the change in soil organic C stocks for mineral soils and organic soils. Change in soil organic C stocks is estimated for mineral soils with land-use conversion to settlements using Equation 2.25 in 2006 IPCC Guidelines (equation No. 7). Emission from mineral soil due to land use change to settlements is accounted according to average carbon stock in forest mineral soil, assuming that carbon accumulated in upper 30 cm (82.6 tonnes C $ha^{-1}$) partially turns into emissions within 20 years (0.8 tonnes C $h^{-1}$ annually). The impact factor ($F_{LU}$ x $F_{MG}$ x $F_I$) is 0.8.

$$\Delta C_{Mineral} = \frac{\left(SOC_0 - SOC_{(0-T)}\right)}{D}$$

$$SOC = \sum_{c,s,i} \left(SOC_{REFc,s,i} \cdot F_{LUc,s,i} \cdot F_{MGc,s,i} \cdot F_{Ic,s,i} \cdot A_{c,s,i}\right), \text{ where}$$

$\Delta C_{Mineral}$ = annual change in carbon stocks in mineral soils, tonnes C $yr^{-1}$;
$SOC_0$ = soil organic carbon stock in the last year of an inventory time period, tonnes C;
$SOC_{(0-T)}$ = soil organic carbon stock at the beginning of the inventory time period, tonnes C;
$D$ = time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr;
$c$ = represents the climate zones;
$s$ = the soil types;
$i$ = the set of management systems that are present∈ a country;
$SOC_{REF}$ = the reference carbon stock, tonnes C $ha^{-1}$;
$F_{LU}$ = stock changefactor for land−use systems or sub-system for a particular land−use, dimensionless;
$F_{MG}$ = stock change factor for management regime, dimensionless;
$F_I$ = stock change factor for input of organic matter, dimensionless;
$A$ = land area of the stratum being estimated, ha. (7)

Land converted to settlements on organic soils within the inventory time period is treated the same as settlements remaining settlements. Carbon losses are computed using equation 2.26 in 2006 IPCC Guidelines.

### 6.8.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of area estimates is provided in Table 6.31.

**Table 6.31 Uncertainty of the settlements use data in 2014**

| Land use category | Number of NFI plots | Share of NFI plots, % | Uncertainty, % |
|---|---|---|---|
| **Settlements** | 661 | 4.1 | 7.8 |
| **settlements remaining settlements** | 570 | 3.5 | 8.7 |
| **organic soil** | 1 | 0.01 | - |
| **other soil** | 569 | 3.5 | 8.7 |

| Land use category | Number of NFI plots | Share of NFI plots, % | Uncertainty, % |
|---|---|---|---|
| **land converted to settlements** | 91 | 0.6 | 19.6 |
| **organic soil** | 12 | 0.1 | 47.0 |
| **other soil** | 78 | 0.5 | 22.0 |

Uncertainty of average carbon stock in litter in forests is 6.1 %, uncertainty of carbon stock in soil layer 0-30 cm is 15.6 %, uncertainty of dead wood stock in forests is 1.7 %, and uncertainty of carbon stock in dead wood is 30 %. Combined uncertainty of carbon stock in dead wood is 30 %. Combined uncertainty of carbon stock change is 14.6 %.

Consistency of time series is secured by using the same activity data (NFI) for the whole period. Extrapolation is used to elaborate prognosis of deforestation for 2009.

Uncertainty of annual carbon stock change factor (EF) for cultivated organic soils in cool temperate climatic temperature regime is ± 18 % (IPCC Wetlands Supplement, Table 2.1).

Uncertainties of emission factors for estimation of $CH_4$ emissions from drained organic soils are indicated under chapter Cropland.

### 6.8.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

The QA/QC plans for the settlements' category include the QC measures based on the 2006 IPCC Guidelines. Specific QA/QC checks across the settlements methodology were done. Potential errors and inconsistencies are documented and corrections are made if necessary. The files and documents used in preparation of the inventory are archived annually and back-up copies are made weekly. Several quality meetings are held annually between experts.

### 6.8.5 Category-specific recalculations

Recalculations are done due to revision of the NFI data based on repeated measurement of borders of the plots and their sectors. Summary of the impact of recalculation on the aggregated net GHG emissions from settlements is shown in Figure 6.16.

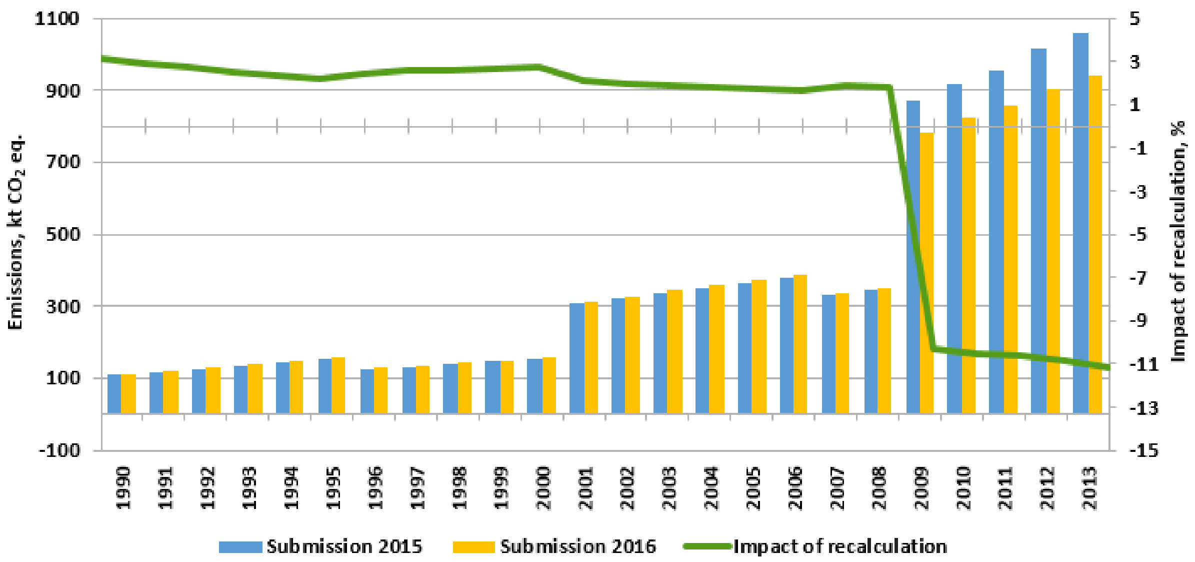


**Figure 6.16 Impact of recalculation on the aggregated net GHG emissions from settlements**

### 6.8.6 Category-specific planned improvements

Lack of knowledge about distribution of settlements with vegetation coverage and without it leads to overestimation of soil emissions, because all settlements are considered as loosing soil carbon, in spite certain area is continuing to sequestrate carbon (like buffer zones around roads); therefore it is important to elaborate method to calculate proportion of settlements with and without vegetation coverage and different methods for calculation of soil carbon losses in these areas. It is planned to use satellite images with high resolution in several pilot areas (representing different economic activity and dominant type of vegetation) in this study.

In spite of ability to calculate carbon stock changes in living and dead biomass since 2004, historical figures cannot be easily restored. It is planned to use high resolution satellite images to evaluate dynamics of carbon stock in living biomass in certain pilot areas since 1990 and to extrapolate obtained results to all NFI plots to avoid potential overestimation of removals of $CO_2$ in living biomass.

Losses in living biomass, dead wood, litter and soil due to conversion of forest land to settlements are reported using Tier 1 approach, resulting in high emissions, which can lead to overestimation or underestimation of actual emissions, therefore Tier 2 approach (based on a single tree accounting in the NFI) will be developed.

## *6.9 OTHER LAND (CRF 4.F)*

According to the 2006 IPCC Guidelines other lands are territories without vegetation like rocks, glaciers as well as the rest of unmanaged lands which are not included in other land use categories. According to the national land use statistics other lands include unmanaged lands, wetlands and settlements (1 459.3 mill. Ha in 2008). Instead of other lands defined by national land use statistics since 2009 the NFI is used to estimate area of other lands. It is assumed that other lands are dunes not covered by woody vegetation. Total area of these lands is considered constant for the whole reporting period (5.44 kha). No GHG emissions or $CO_2$ removals are reported in this category.

## *6.10 BIOMASS BURNING (CRF 4(V))*

Source category descriptionThis source category includes greenhouse gas emissions ($CO_2$, $CH_4$, $N_2O$) and other emissions ($NO_x$ and CO) from biomass burning on forest land comprising wildfires and controlled burning, as well as wildfires in grassland. Total aggregated emissions from biomass burning in 2014 were 110.2 kt of $CO_2$ eq. (Figure 6.17).

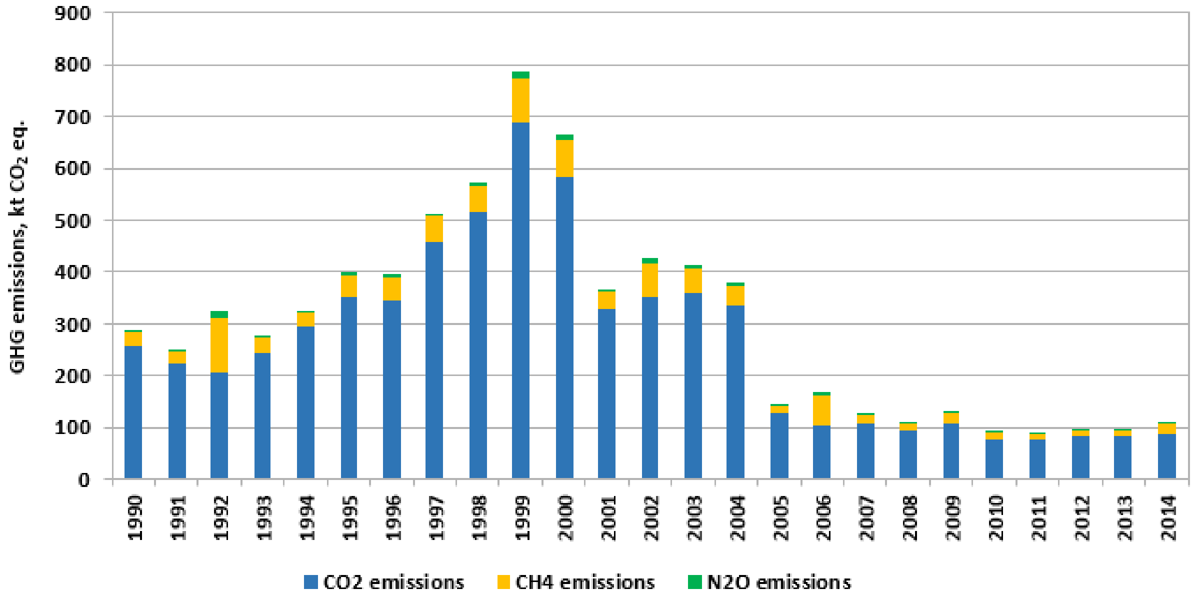


**Figure 6.17 Aggregated emissions from biomass burning (kt $CO_2$ eq.)**

Biomass burning occurs in forest land and grassland. Taking into account that wetlands (bogs and fens) belong to forest land according to national land use definitions, emissions associated with wildfires in wetlands cannot be separated and are reported under forest lands remaining forests. No evidences of forest fires or grassland wildfires are found in land converted to forest in the NFI plots having special forest land category – burnt forest; therefore it is considered that no forest fires takes place in afforested area. The approach used in the Latvia's GHG inventory (reporting emissions under land use categories according to national statistics) secures that emissions from biomass burning are not overlapping.

The area statistics on forest wildfires are compiled by the State forest service and they are based on information given by the local units. Area of forest fires and biomass in burned area is shown in Figure 6.18.

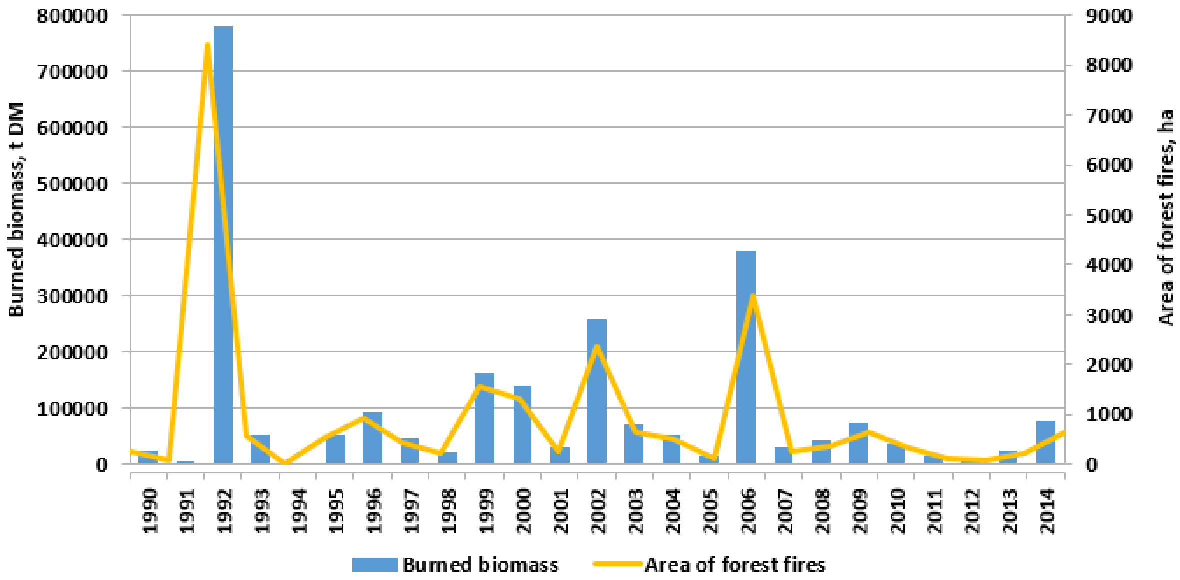


**Figure 6.18 Area of forest fires and biomass in burned area**

Area of grassland burning is provided by the State fire safety service (SFSS), cartographic information about location of wildfires in grasslands since 2005 is provided by the Rural Support Service. Wildfires in grasslands are more common in south eastern part of the country and around Riga. Concentration of wildfires in the south-east correlates with area of abandoned farmlands. Total area of burned grassland is shown in Table 6.32. For 1990-1992 no statistical information exists. It was decided to use extrapolated burned area of following years period for 1990-1992 instead of notification key NO.

**Table 6.32 Burned area of grassland since 1990**

| Year | Area, ha |
|---|---|
| **1990** | 555 |
| **1991** | 893 |
| **1992** | 1232 |
| **1993** | 21 |
| **1994** | 98 |
| **1995** | 526 |
| **1996** | 1 224 |
| **1997** | 576 |
| **1998** | 1 255 |
| **1999** | 2 685 |
| **2000** | 2 262 |
| **2001** | 4 800 |
| **2002** | 11 547 |
| **2003** | 14 335 |
| **2004** | 6 717 |
| **2005** | 2 027 |
| **2006** | 25 806 |
| **2007** | 4 048 |
| **2008** | 1 170 |
| **2009** | 4 462 |

| Year | Area, ha |
|---|---|
| **2010** | 2 495 |
| **2011** | 1 618 |
| **2012** | 1 872 |
| **2013** | 1 885 |
| **2014** | 6 819 |
| **Total** | 98 248 |

Emissions from biomass burning are represented by incineration of harvesting residues during forest logging operations. The activity data for this calculation was based on an outdated study until 2010[229]. Now a questionnaire for private forest owners on utilization of harvesting residues is used[230]. This switch leads to reduction of emissions in 2005. In case of on-site incineration of harvesting residues during commercial harvesting, all emissions also are applied to the forest land remaining forest land category, because no commercial felling takes place in young stands (younger than 20 years) on land converted to forest land.

## 6.10.1 Methodological issues

Tier 1 and 2 methods of calculation provided in the 2006 IPCC Guidelines were utilized. Emissions from any type of fires were calculated using equation 2.27 of the 2006 IPCC Guidelines:

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3}; \text{ where}$$

$L_{fire}$ – amount of greenhouse gas emissions from fire, tonnes of each GHG e.g. $CH_4$, $N_2O$, etc.;

$A$ = area burnt, ha;

$M_B$ = mass of fuel available for combustion, tonnes ha$^{-1}$. This includes biomass, ground litter and dead wood. When Tier 1 methods are used then litter and dead wood pools are assumed zero, except where there is a land-use change;

$C_f$ = combustion factor, dimensionless;

$G_{ef}$ = emission factor, g kg$^{-1}$ dry matter burnt. (8)

### 6.10.1.1 Forest wildfires

Tier 1 method and default emission factors of calculation provided in the 2006 IPCC Guidelines was utilized. Amount of burned biomass is considered according to average growing stock of living biomass, dead wood and litter in a particular year. Combustion efficiency or fraction of biomass combusted (dimension-less) is considered 0.45 according to Table 2.6 of 2006 IPCC Guidelines[231]. Factors of emissions are shown in Table 6.33.

**Table 6.33 Emission factor for each GHG (g kg$^{-1}$ dry matter burned)**

| Gas | $CH_4$ | CO | $N_2O$ | $NO_x$ | $CO_2$ |
|---|---|---|---|---|---|
| Emission factor | 6.1±2.2 | 78±31 | 0.06 | 1.1±0.6 | 1550±95 |

*[229] Leonards Līpiņš, "Assessment of wood resources and efficiency of wood utilization (Koksnes izejvielu resersu un to izmantošanas efektivitātes novērtējums)" (LLU, 2004), http://www.zm.gov.lv/index.php?sadala=258&id=803.*

*[230] Lazdiņš, A., Lazdiņa, D., 2013. Meža ugunsgrēku un mežizstrādes atlieku dedzināšanas radītās siltumnīcefekta gāzu emisijas Latvijā (Greenhouse gas emissions in Latvia due to incineration of harvesting residues and forest fires), in: Referātu Tēzes. Presented at the Latvijas Universitātes 71. zinātniskā konference "Ģeogrāfija, ģeoloģija, vides zinātne", Latvijas Universitāte, Rīga, pp. 133–137.*

*[231] Combustion factor values (proportion of prefire biomass consumed) for fires in a range of vegetation types.*

#### 6.10.1.2 Grassland wildfires

Tier 1 method and default emission factors of calculation provided in the 2006 IPCC Guidelines was utilized. Emissions from wildfires in grassland were calculated using equation 2.27 of the 2006 IPCC Guidelines. Mass of available fuel in grassland's fires – 2.1 t dm $ha^{-1}$ (Table 2.4 of 2006 IPCC Guidelines[232]), fraction of the biomass combusted 0.74 (Table 2.6 of 2006 IPCC Guidelines[233]). Factors of emissions for grassland fires are shown in Table 6.34.

**Table 6.34 Emission factors for grassland's wildfires[234]**

| No | Gas | Factor, g $kg^{-1}$ dry matter burned |
|---|---|---|
| 1. | CO | 65±20 |
| 2. | $CH_4$ | 2.3±0.9 |
| 3. | $NO_x$ | 3.9±2.4 |
| 4. | $N_2O$ | 0.21±0.10 |

#### 6.10.1.3 Controlled fires in forests

Tier 2 method and default emission factors of calculation provided in the 2006 IPCC Guidelines was utilized. Emissions from controlled fires were calculated considering average stock of harvesting residues (BEF for conversion of stem biomass to above-ground biomass), which considerably increased due to increase of estimates of harvesting stock. Factors of emissions are shown in Table 6.33. The following assumptions have been made for burned harvesting residues calculation:

- 1990 to 2000 – 50 % of harvesting residues are left for incineration and 67 % of the left residues are incinerated, the rest are left to decay;
- 2001 to 2004 – 30 % of harvesting residues are left for incineration and 67 % of the left residues are incinerated, the rest are left to decay;
- 2005 to 2009 – 7 % of harvesting residues are left for incineration and 100 % of the left residues are incinerated; the rest of the residues are left for decay or extracted for bioenergy production.
- starting from 2010 – 4 % of harvesting residues are left for incineration and 100 % of the left residues are incinerated; the rest of the residues are left for decay or extracted for bioenergy production.

$CO_2$ emissions are calculated only from wildfires taking into account that carbon located in harvesting residues is already accounted as losses in living biomass. Incinerated residues are extracted from removals in dead wood.

### 6.10.2 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

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*[232] Fuel (dead organic matter plus live biomass) biomass consumption values for fires in a range of vegetation types.*
*[233] Combustion factor values (proportion of prefire biomass consumed) for fires in a range of vegetation types.*
*[234] IPCC 2006 Table 2.5 Emission factors (g $kg^{-1}$ dry matter burned) for various types of burning.*

Uncertainty in activity data (area) for biomass burning is estimated at ± 10 % based on expert judgement. Uncertainty concerning combustion efficiencies in combined is ± 10 % according to the expert judgement. Uncertainties in emission factors are based on the 2006 IPCC Guidelines default values.

### 6.10.3 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

Quality control procedures named in 2006 IPCC Guidelines were done. Possible overlapping in emission/removal estimation with other sources has been checked as far as it is possible on the base of existing data. Land areas of wildfires and controlled burning were reviewed with latest statistics. It was confirmed that all data used in this section cover whole land area of Latvia. Several quality meetings are held annually between experts.

### 6.10.4 Category-specific recalculations

Only minor changes have been occurred (< 0.6%) due to the more accurate activity data. Summary of the impact of recalculation on the aggregated net GHG emissions from biomass burning is shown in Figure 6.19.

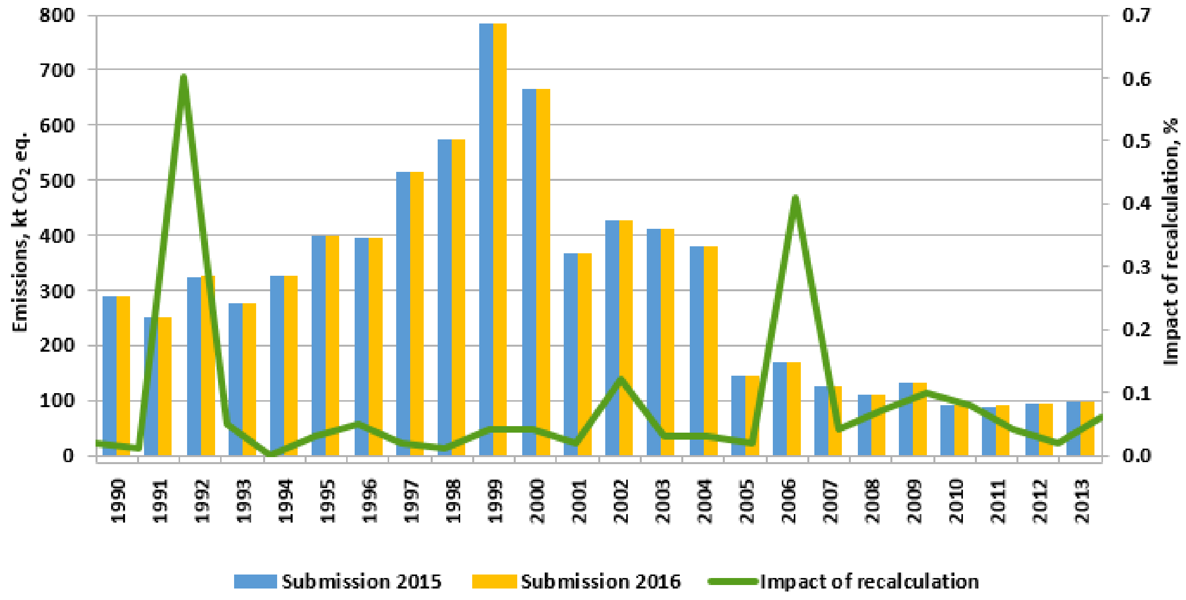


**Figure 6.19 Impact of recalculation on the aggregated net GHG emissions from biomass burning**

### 6.10.5 Category-specific planned improvements

A new methodology on estimation of incineration efficiency in forest fires will be elaborated and different types of forest fires will be separated to account the GHG emissions more accurate. Information provided by the State forest service will be used with higher level of accuracy by splitting different types of forest fires and following activities in the forest stands to avoid double accounting of harvested wood extracted in sanitary felling after forest fires. Burning of harvesting residues will be evaluated by forest owners questionnaires.

## *6.11 HARVESTED WOOD PRODUCTS (CRF 4.G)*

### 6.11.1 Category description

The category harvested wood products is a key source of $CO_2$ removals. The net emissions in harvested wood category in 2014 were -1818 kt $CO_2$. The net emissions during the reporting period are shown in Figure 6.20. Increase of removals in the harvested wood products during the last decade is associated with increase of harvesting rate and implementation of more advanced timber processing technologies.

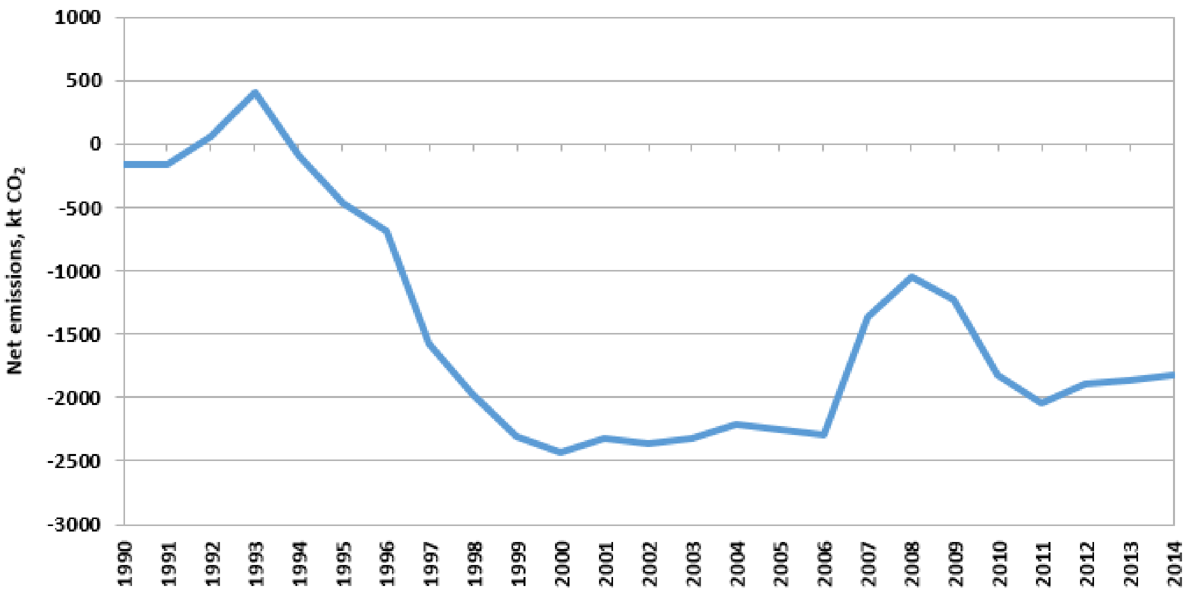


**Figure 6.20 Net emissions from HWP during period 1990-2014 (kt)**

Net emissions due to production of the harvested wood products are calculated according to methodology in IPCC KP Supplement. $CO_2$ emissions due to oundwood production in deforested land are accounted using instantaneous oxidation method.

### 6.11.2 Methodological issues

The net emissions from the harvested wood products are calculated according to the methodology elaborated by S. Rüter, 2011. The methodology corresponds to Tier 2 for HWP in IPCC KP Supplement for HWP. Three main HWP groups are used in calculations – sawnwod, wood based panels and paper and paperboard with more detailed division on products in Table 6.35 (according to Table 2.8.1 of IPCC KP Supplement).

**Table 6.35 HWP categories and their subcategories**

| HWP category | HWP subcategory |
|---|---|
| **Sawn wood** | Coniferous sawnwood |
| | Non-coniferous sawnwood |
| **Wood-based panels** | Hardboard (HDF) |
| | Insulating board (Other board, LDF) |

| HWP category | HWP subcategory |
|---|---|
| | Fibreboard compressed |
| | Medium-density fibreboard (MDF) |
| | Particle board |
| | Plywood |
| | Veneer sheets |
| **Paper and paperboard** | - |

The calculation is based on harvesting statistics collected by the State forest service, production statistics by the Forest industry association, FAO and EUROSTAT. Linkage with land area used in the commercial felling is secured through the State forest service stand wise forest inventory system, where all commercial harvesting activities are recorded. Only locally harvested wood is accounted in estimates.

The proportion is calculated by equation No. 9 to estimate share of harvesting stock extracted due to deforestation and is used to calculate share of domestic industrial oundwood. The data to calculate proportion is obtained from Central statistical bureau of Latvia and is collected by the State forest service. This proportion is applied to HWP to estimate how much HWP could be produced from wood obtained in deforested areas. Instant oxidation is applied to the proportion of HWP potentially produced from the wood obtained in deforested areas.

$$IRW_P(i)=\left(1-\frac{D*M_{avg}}{MH_{total}}\right)*IRW_{total}(i);\ where$$

$IRW_P(i)=$ *production of industrial roundwood excluding roundwood from deforested area in year i, Gg C yr*$^{-1}$;
$D$ = *annual deforested area, ha;*
$M_{avg}$ = *average growing stock in country,* $m^3 ha^{-1}$;
$MH_{total}$ = *total harvested stock volume,* $m^3$;
$IRW_{total}(i)$ = *total industrial domestic roundwood production.*

(9)

Historical data on production, import and export of HWP as well as share of different types of the products are used in calculation. The coefficients and numeric values used in calculation are default conversion factors recommended in IPCC KP Supplement (Table 2.8.1) and are provided in Table 6.36 and Table 6.37. Input data in calculation are extrapolated to 1900. Net emissions due to decay of harvesting residues are accounted separately considering 20 years transition period for above and below ground biomass. Instant oxidation is considered for the firewood assortment.

**Table 6.36 Assumptions for estimation of carbon stock in harvested wood products**

| HWP categories | Density (oven dry mass over air dry volume), Mg m$^{-3}$ | C conversion factor (per air dry volume), C m$^{-3}$ |
|---|---|---|
| **Sawnwood – Coniferous** | 0.450 | 0.225 |
| **Sawnwood – Non-Coniferous** | 0.560 | 0.280 |
| **Veneer sheets** | 0.505 | 0.253 |
| **Plywood** | 0.542 | 0.267 |
| **Particle board** | 0.596 | 0.269 |
| **Hardboard** | 0.788 | 0.335 |
| **MDF (Medium density fibreboard)** | 0.691 | 0.295 |
| **Fibreboard compressed** | 0.739 | 0.315 |

| HWP categories | Density (oven dry mass over air dry volume), Mg m$^{-3}$ | C conversion factor (per air dry volume), C m$^{-3}$ |
|---|---|---|
| **Insulating board** | 0.159 | 0.075 |
| - | **oven dry mass over air dry mass, Mg Mg$^{-1}$** | **per air dry mass, Mg C Mg$^{-1}$** |
| **Paper and paperboard (aggregate)** | 0.900 | 0.386 |

Share of locally originated wood in harvested wood products is calculated using equation No. 10.

$$f_{IRW}(i) = \frac{IRW_P(i) - IRW_{EX}(i)}{IRW_P(i) + IRW_{(IM)}(I) - IRW_{EX}(i)};\ where$$

$f_{IRW}(i)$ = share of industrial roundwood for the domestic production of HWP originating from domestic forests in year i;

$IRW_P(i)$ = production of industrial roundwood excluding roundwood from deforested area in year i, $Gg\ C\ yr^{-1}$;

$IRW_{EX}(i)$ = export of industrial roundwood in year i, $Gg\ C\ yr^{-1}$;

$IRW_{(IM)}(I)$ = import of industrial roundwood in year i, $Gg\ C\ yr^{-1}$. (10)

Organic carbon in harvested wood products originated from domestic wood is calculated using equation No. 11.

$$CHWP = f_{IRW}(i) * HWP_D;\ where$$

$CHWP$ = organic carbon in domestically produced HWP excluding HWP from wood produced in deforested area, $Gg\ C\ yr^{-1}$;

$HWP_D$ = Domestical production of HWP, $Gg\ C\ yr^{-1}$. (11)

The rate of the $CO_2$ emissions and removals in harvested wood products is calculated using equations No. 12 and 13.

$$C(i+1) = e^{-k} * C(i) + \left[\frac{1-e^{-k}}{k}\right] * inflow(i);\ where$$

$C(i+1)$ = annual carbon stock, $Gg\ C\ yr^{-1}$;

$e$ = exponential constant;

$k$ = decay constant for each HWP category, units $yr^{-1}$;

$C(i)$ = carbon stock in particular category at the begining of year i, Gg C;

$inflow(i)$ = the inflow to the particular HWP category during year i, $Gg\ C\ yr^{-1}$;

$$k = \frac{\ln(2)}{HL};\ where$$

$HL$ = the number of years it takes to lose one-half of the material currently in the pool, yr (12)

$$\Delta C(i) = C(i+1) - C(i);\ where$$

$\Delta C(i)$ = carbon stock change of the HWP category during year i, $Gg\ C\ yr^{-1}$. (13)

**Table 6.37 Common coefficients to estimate balance between $CO_2$ emissions and removals in harvested wood products**

| Factors | Numeric value | | |
|---|---|---|---|
| **Common coefficients** | | | |
| **e** | 2.718282 | | |
| **ln(2)** | 0.6931 | | |
| **Assortment specific coefficients:** | | | |
| **Assortment** | **Sawnwood** | **Platewood** | **Pulpwood** |
| **HL** | 35 | 25 | 2 |
| **k** | 0.02 | 0.03 | 0.35 |
| **$e^{-k}$** | 0.98 | 0.97 | 0.71 |
| $k = \frac{1-\ln(2)}{H*L}$ | 0.99 | 0.99 | 0.85 |

The equations of calculation of the harvested wood products are included into the National tool for calculation of the net emissions due to forest management as separate module.

### 6.11.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty level of the activity data for the whole time series is assumed 15 % in 1990-2014.

### 6.11.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

Harvesting rate and production of harvested wood products used in the calculations is compared with other data sources, particularly statistics collected by the Latvia Forest industry federation. Several quality meetings are held annually between experts.

### 6.11.5 Category-specific recalculations, if applicable, including changes made in response to the review process

Changes have been occurred due to the more accurate activity data in years 2011-2013. Summary of the impact of recalculation on $CO_2$ emissions from HWP is shown in Figure 6.21.

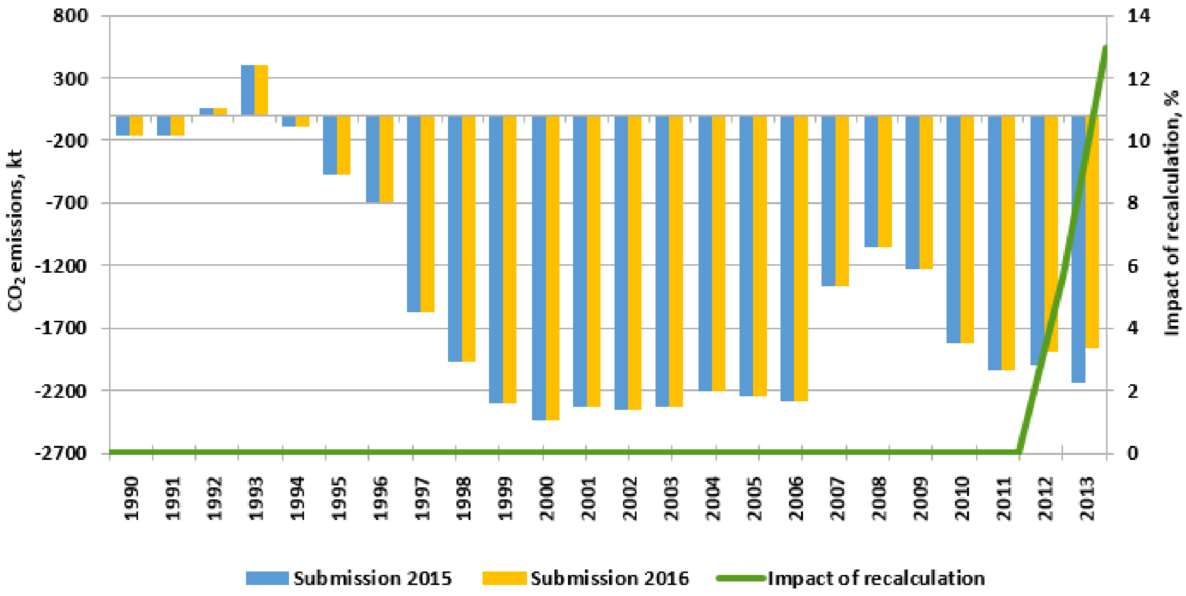


**Figure 6.21 Impact of recalculation on $CO_2$ emissions from HWP**

### 6.11.6 Category-specific planned improvements

There are no improvements planned for the next inventory.

## 6.12 DIRECT $N_2O$ EMISSIONS FROM MANAGED SOILS

### 6.12.1 Category description

Direct $N_2O$ emissions from drainage of organic soils are estimated for forest lands, croplands, settlements and wetlands land-use categories. Direct $N_2O$ emissions corresponding to land-use change from N mineralisation associated with loss of soil organic matter from change of land use or management are estimated for land-use change to croplands and settlements on mineral soils.

### 6.12.2 Methodological issues

Direct emissions of $N_2O$ due to drainage of organic soils are calculated according equation No. 14 (Equation 2.7 of the IPCC Wetlands Supplement).

$$N_2O-N_{OS}=\left[\left(F_{OS,CG,Temp}\cdot EF_{2CG,Temp}\right)+\left(F_{OS,F,Temp,NR}\cdot EF_{2F,Temp,NR}\right)\right];\ where$$

$N_2O-N_{OS}$ = Annual direct $N_2O-N$ emissions from managed/drained organic soil, $kg\ N_2O-N\ yr^{-1}$

$F_{OS}$ = Annual area of managed/drained organic soils, ha. The subscripts CG, F, Temp, NR refer to cropland and grassland, forestland, temperate and nutrient rich, respectively.

$EF_2$ = Emission factor for $N_2O$ emissions from drained/managed organic soils, $kg\ N_2O\text{–}N\ ha^{-1}yr^{-1}$ (14)

Activity data consist of areas of land remaining in a land-use category and land converted to other land-use category on drained organic soils. Data of annual area of drained organic soil are taken from the NFI. Default $N_2O$ emission factors for drained organic soils are shown in Table 6.38 according Table 2.5 of the IPCC Wetlands Supplement.

**Table 6.38 Tier 1 $N_2O$ emission/removal factors for drained organic soils in all land-use categories**

| Land-use category | Climate/ vegetation zones | Emission factor (kg $N_2O$-N $ha^{-1}$ $yr^{-1}$) | 95% Confidence interval | |
|---|---|---|---|---|
| **Forest land, drained** | Temperate | 2.8 | -0.57 | 6.1 |
| **Cropland, drained** | Boreal and temperate | 13 | 8.2 | 18 |
| **Grassland, deep-drained, nutrient-rich** | Temperate | 8.2 | 4.9 | 11 |
| **Peatland managed for extraction** | Boreal and temperate | 0.3 | -0.03 | 0.64 |

$N_2O$ emissions from land converted to another land-use category on drained organic soils are calculated in the same way as emissions from land remaining in a land-use category.

Direct $N_2O$ emissions from N inputs to managed soils and from N mineralisation resulted from loss of soil organic C stocks in mineral soils due to land-use change are estimated by Tier 1 methodology using equation No. 15 (equation 11.1 of 2006 IPCC Guidelines):

$$N_2O - N_{N\ inputs} = F_{SOM} * EF_1;\ where$$

$N_2O - N_{N\ inputs}$ – annual direct $N_2O - N$ emissions from N inputs to managed soils, kg $N_2O - N\ yr^{-1}$

$EF_1$ – emission factor for N mineralised from mineral soil as a result of loss of soil carbon, kg $N_2O - N\ (kg\ N)^{-1}$ (15)

The equation No. 15 is supplemented by equation 11.8 from 2006 IPCC Guidelines (equation No. 17 in the NIR). Default emission factor for N mineralised from mineral soil as a result of loss of soil carbon (0.01 kg N2O-N (kg N)-1) from Table 11.1 of 2006 IPCC Guidelines is used. Default C:N ratio (15) for soil organic matter is utilized for estimation of annual amount of N mineralised in mineral soils as a result of loss of soil carbon due to land use change to cropland (2006 IPCC Guidelines). As there is no fixed default emission factors for settlements provided by IPCC guidelines, default emission factors of croplands land-use category are applied, C:N ratio for soil organic matter applied based on expert judgement is 15, and annual carbon losses in organic soil in settlements are accounted using emissions factor from cropland – 5 t C ha-1 yearly (2006 IPCC Guidelines), assuming that peat is not completely removed during the conversion.

### 6.12.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of soil nitrogen ($N_2O$) emissions are estimated according to data obtained within the scope of the international forest soil monitoring project BioSoil and values provided in the 2006 IPCC Guidelines. Uncertainty ranges of emission factors for $N_2O$ emissions from drained organic soils are listed in Table 6.38.

Uncertainty range of emission factor for N mineralised from mineral soil as a result of loss of soil carbon is 0.003-0.03 kg $N_2O$-N (kg N)$^{-1}$. Uncertainty range of C:N ratio of the soil organic matter for land-use change is 10-30.

### 6.12.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

QA/QC procedures include double check of area affected by the land use change and soil $CO_2$ emissions – under calculation of land use changes and during calculation of $N_2O$ emissions. Several quality meetings are held annually between experts.

### 6.12.5 Category-specific recalculations

Recalculations are done due to recalculation of the NFI data based on repeated measurement of borders of the plots and their sectors. Summary of the impact of recalculation on indirect N2O emissions from managed soils is shown in Figure 6.22.

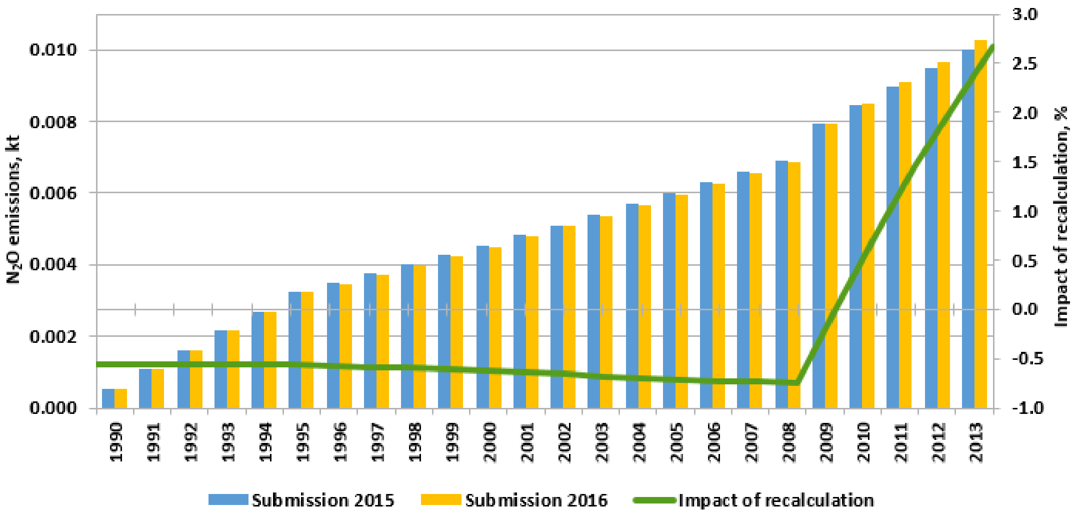


**Figure 6.22 Impact of recalculation on indirect $N_2O$ emissions from managed soils**

### 6.12.6 Category-specific planned improvements

$N_2O$ emissions might be considerable part of emissions from wetlands, therefore, it is necessary to develop method for estimation impact of drainage on $N_2O$ emissions, and it is important to be able to separate wetlands on organic soils (high $N_2O$ emissions) and mineral soils (low $N_2O$ emissions).

## *6.13 INDIRECT $N_2O$ EMISSIONS FROM MANAGED SOILS (CRF 4 (IV))*

### 6.13.1 Category description

Indirect $N_2O$ emissions from N mineralisation associated with loss of soil organic matter from change of land use or management are estimated for land-use change to croplands and settlements on mineral soils. Indirect $N_2O$ emissions from organic soils are not calculated, because 2006 IPCC Guidelines does not include such a methodology.

### 6.13.2 Methodological issues

Indirect $N_2O$ emissions from land use change to cropland are calculated according to 2006 IPCC Guidelines. Amount of $N_2O$-N emissions produced from leaching and run-off as a result from land use change to cropland are estimated by Tier 1 methodology using equation 11.10 (equation No. 16 in the NIR).

$$N_2O_{(L)} - N = F_{SOM} * Frac_{LEACH\text{-}H} * EF_5;\ where$$

$N_2O_{(L)} - N$ – annual amount of $N_2O - N$ produced from leaching and runoff of N additions to managed soils where leaching/runoff occurs, kg $N_2O - N\ yr^{-1}$

$Frac_{LEACH\text{-}(H)}$ – fraction of all N added to/ mineralised in managed soils in regions where leaching/ runoff occurs that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$

$EF_5$ – emission factor for $N_2O$ emissions from leaching and runoff, kg $N_2O - N$ (kg N leached and runoff )$^{-1}$) (16)

It is supplemented by equation 11.8 from 2006 IPCC Guidelines (equation No. 17 in the NIR).

$$F_{SOM} = \left(\Delta C_{Mineral} * \frac{1}{R}\right) * 1000;\ where$$

$F_{SOM}$ – the net annual amount of N mineralised in mineral soils as a result of loss of soil carbon throught chenge in land use or management, kg N .

$\Delta C_{Mineral}$ – average annual loss of soil carbon for land – use type, tonnes C

$R - C:N$ ratio of the soil organic matter (17)

Default C:N ratio (15) for soil organic matter (2006 IPCC Guidelines) is utilized for estimation of annual amount of N mineralised in mineral soils as a result of leaching/run-off associated with loss of soil carbon through land use change to cropland. Carbon losses are calculated according to the Tier 1 method of the 2006 IPCC Guidelines. Default values of fraction of all N added to/mineralised in managed soils due to leaching and run-off (0.3 kg N (kg of N additions)$^{-1}$) and emission factor for $N_2O$ emissions from N leaching and run-off (0.0075 kg $N_2O$-N (kg N leached and run-off)$^{-1}$) are taken from table 11.3 of 2006 IPCC Guidelines.

Indirect $N_2O$ emissions from land use change to settlements are also accounted using the 2006 IPCC Guidelines Tier 1 method. Amount of $N_2O$-N emissions produced from leaching and run-off as a result from land use change to settlements are estimated by Tier 1 methodology using equation 11.10 supplemented by equation 11.8 from 2006 IPCC Guidelines. C:N ratio 15 for soil organic matter based on expert judgement is utilized for estimation of annual amount of N mineralised in mineral soils as a result of leaching/run-off associated with loss of soil carbon thorough land use change to settlements. Tier 1 method of the 2006 IPCC Guidelines (loss of 20 % of soil carbon in land converted to settlement) is used to estimate carbon stock changes. Default values of fraction of all N added to mineralised in managed soils due to leaching and run-off (0.3 kg N (kg of N additions)$^{-1}$) and emission factor for $N_2O$ emissions from N leaching and run-off (0.0075 kg $N_2O$-N (kg N leached and run-off)$^{-1}$) are taken from table 11.3 of 2006 IPCC Guidelines.

### 6.13.3 Uncertainties and time-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty range of C:N ratio of the soil organic matter for land-use change from Forest Land or Grassland to Cropland is 10-30 %. Uncertainty range of fraction of all N added to/mineralised in managed soils in regions where leaching/run-off occurs that is lost through leaching a run-off is 0.1-0.8 kg N (kg of N additions$^{-1}$). Uncertainty range of emission factor for $N_2O$ emissions from N leaching and run-off according to 2006 IPCC Guidelines is 0.0005-0.025 kg $N_2O$-N (kg N leached and run-off$^{-1}$).

### 6.13.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives. QA/QC procedures include double check of area affected by the land use change and soil $CO_2$ emissions – under calculation of land use changes and during calculation of $N_2O$ emissions. Several quality meetings are held annually between experts.

### 6.13.5 Category-specific recalculations

Recalculations are done due to recalculation of the NFI data based on repeated measurement of borders of the plots and their sectors. Summary of the impact of recalculation on indirect $N_2O$ emissions from managed soils is shown in Figure 6.23.

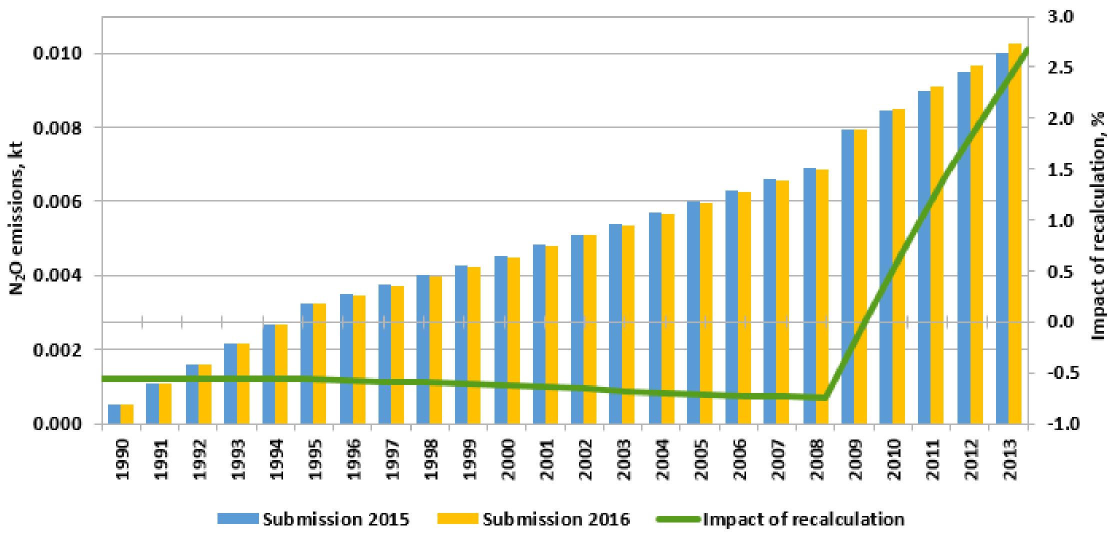


**Figure 6.23 Impact of recalculation on indirect $N_2O$ emissions from managed soils**

### 6.13.6 Category-specific planned improvements

Information on land use changes, particularly, distribution of organic and mineral soil and losses of carbon due to land use changes should be estimated. Country specific C/N ratio will be introduced after completion of the EEA grants project "Evaluation of carbon stock in cropland and grassland".

# 7 WASTE (CRF 5)

## 7.1 OVERVIEW OF SECTOR

In 2014, emissions from the Waste sector were 836.99 kt $CO_2$ equivalents; it contributes about 7.4% of total GHG emissions (excluding LULUCF) (Figure 7.1). Solid waste disposal and wastewater handling are the main sources of GHG emissions in Waste sector. Incineration and Biological treatment of solid waste (composting) tohether contributes only 5.2% of GHG emissions from Waste sector in 2014.

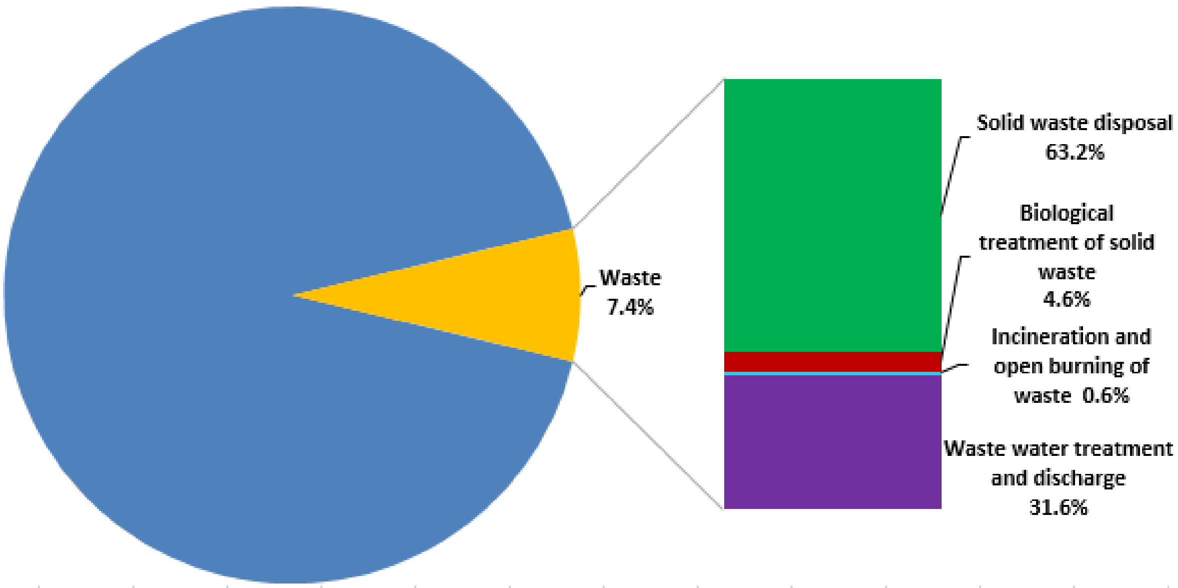


**Figure 7.1 Emissions from the waste sector compared with the total emissions in 2014**

Emission categories reported under Waste sector as well as methods and emission factors used are summarized in Table 7.1.

**Table 7.1 Waste sector reported emissions and methods**

| Sector categories | Reported GHG | Methods | EF |
|---|---|---|---|
| A. Solid waste disposal | | | |
| 1. Managed waste disposal sites | $CH_4$ | Tier 2 (D) | CS, D |
| 2. Unmanaged waste disposal sites | $CH_4$ | Tier 2 (D) | CS, D |
| 3. Uncategorized waste disposal sites | NO | NA | NA |
| B. Biological treatment of solid waste | | | |
| 1. Composting | $CH_4$, $N_2O$ | Tier1 (D) | CS, D |
| 2. Anaerobic digestion at biogas facilities | NA | NA | NA |
| C. Incineration and open burning of waste | | | |
| 1. Waste incineration | $CO_2$, $N_2O$ | D | D |
| 2. Open burning of waste | NE | NA | NA |
| D. Wastewater treatment and discharge | | | |
| 1. Domestic wastewater | $CH_4$, $N_2O$ | D | CS, D |
| 2. Industrial wastewater | $CH_4$, $N_2O$ | D | CS, D |
| 3. Other (as specified in table 6.B) | NMVOC | D | D |
| E. Other (please specify) | NO | NA | NA |

GHG emissions from Waste sector have been fluctuated from 1990-2014. In 2014, emissions were approximately 3.2% higher than in 1990. In 2014, emissions from the Waste sector were 836.99 kt $CO_2$ equivalents; it contributes about 7.4% of total GHG emissions (excluding LULUCF).

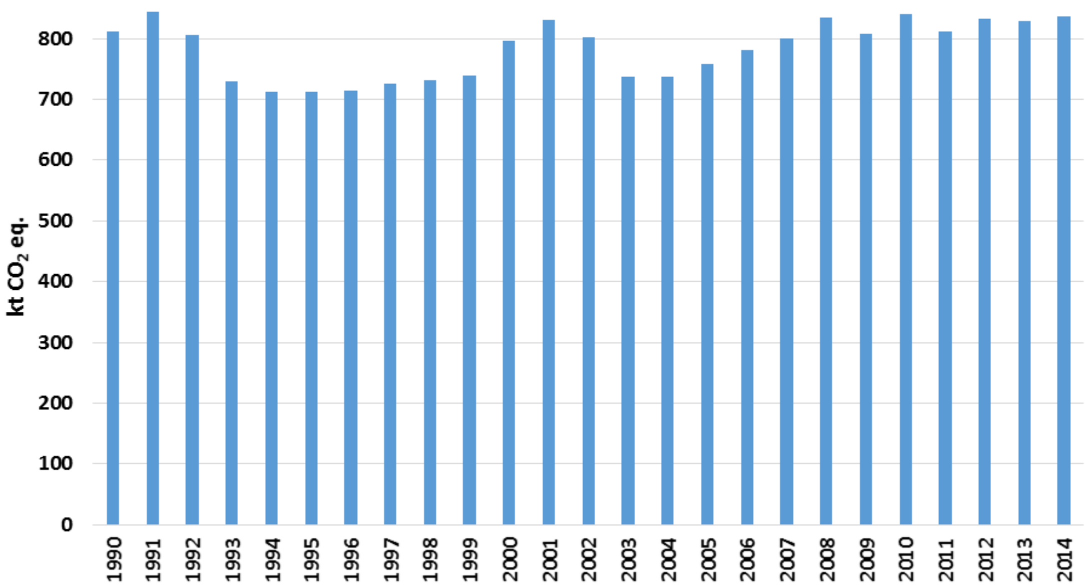


**Figure 7.2 Total GHG emissions from Waste sector 1990-2014 (kt $CO_2$ eq.)**

Fluctuations in total GHG emissions in waste sectors could be explained with changes of economic situation in last 20 years (Figure 7.2). Some industry sectors were almost closed in the middle of 1990s. Biggest influence to total emission trend in the beginning on 1990s gives GHG emissions from Waste water handling, decrease of total emissions in years 2002-2004 is due to starting of methane collection in landfills.

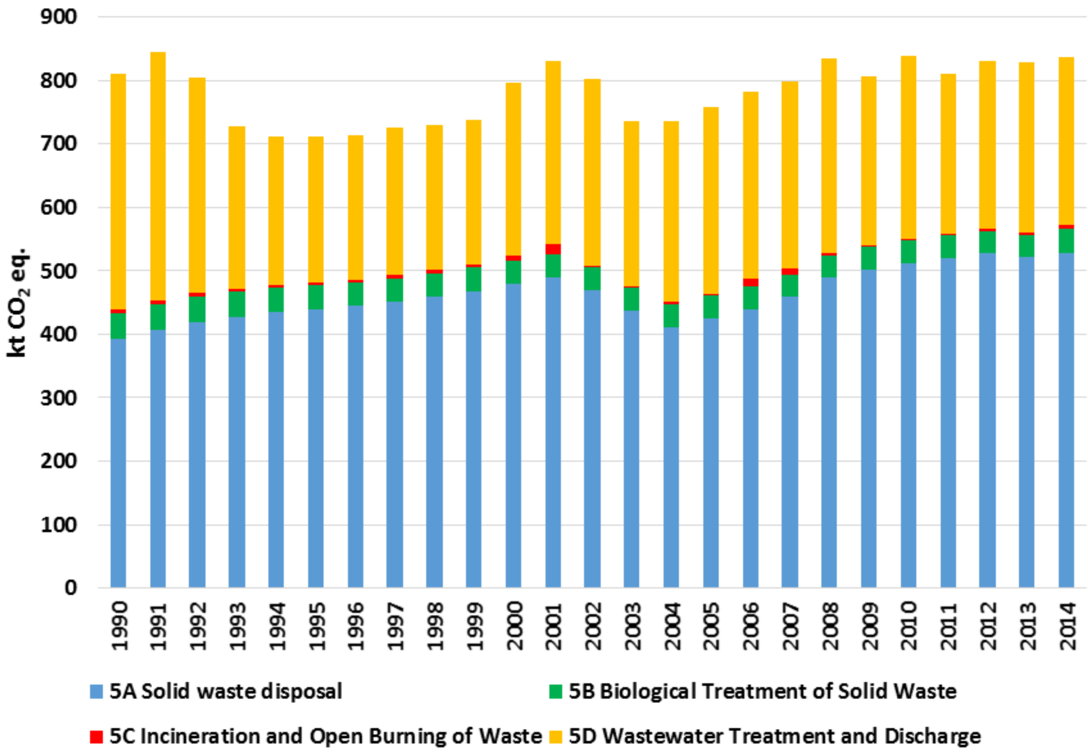


**Figure 7.3 GHG Emissions in Waste subsectors 1990-2014 (kt $CO_2$ eq.)**

Emissions from 5.C and 5.B in last year's, when emissions from these sectors were calculated, are very small in comparison with other sectors – 5.A Solid waste disposal (SWD) and 5.D Waste water treatment and discharge (WWH).

Key categories from Waste sector are summarized in Table 7.2.

**Table 7.2 Key categories in Waste sector in 2014**

| IPCC category/Group | Gas | Identification criteria | with LULUCF | without LULUCF |
|---|---|---|---|---|
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | L1, L2 | X | X |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | L1, L2,T1,T2 | X | X |
| 5.B.1. Composting | $CH_4$ | L2,T2 | | X |
| 5.B.1. Composting | $N_2O$ | L2,T2 | | X |
| 5.D.1 Domestic Wastewater | $CH_4$ | L1, L2,T1,T2 | X | X |
| 5.D.1 Domestic Wastewater | $N_2O$ | L2,T2 | | X |
| 5.D.2 Industrial Wastewater | $CH_4$ | L1, L2,T1,T2 | X | X |

According to the annual waste statistics report[235] the total generated amount of waste is shown in Table 7.3.

**Table 7.3 Generated waste in Latvia (kt)**

| Year | Municipal (all non-hazardous) waste | Hazardous waste | Total |
|---|---|---|---|
| **2006** | 1420.46 | 54.372 | 1474.832 |
| **2007** | 1386.57 | 41.605 | 1428.175 |

[235] *http://www.lvgmc.lv/lapas/vide/atkritumi/atkritumu-statistikas-apkopojumi/atkritumu-statistikas-apkopojumi?id=1713&nid=380*

| | | | |
|---|---|---|---|
| **2008** | 1368.79 | 46.400 | 1415.160 |
| **2009** | 1033.91 | 55.563 | 1089.473 |
| **2010** | 1131.404 | 55.089 | 1186.493 |
| **2011** | 1535.057 | 58.476 | 1593.533 |
| **2012** | 1799.440 | 85.121 | 1884.561 |
| **2013** | 1902.007 | 109.23 | 2011.237 |
| **2014** | 2128.725 | 80.978 | 2209.703 |

$N_2O$ is emitted as the release from sewage purification system and waste incineration.

Data on $CO_2$ and $N_2O$ emissions from waste incineration are available only since 1999. Emissions are estimated since 1990, data on incinerated amount 1990 – 1998 are extrapolated according to waste amounts. Calculation of indirect GHG emissions from cremation is shown in Section 7.4.1.1. Emissions from waste incineration with energy recovery are allocated under Energy sector (CRF 1.A.2.f Non-metalic minerals).

$CH_4$ and $N_2O$ are emitted from waste composting. Enterprises data available only since 2003, when composting facilities started to report within state statistical survey about waste composting. Emissions from household waste composting are estimated since 1990. For emission calculations 2006 IPCC Guidelines and default emission factors were used.

Waste management has acquired prior significance in the environmental protection policy as one of the instruments for sustainable use of natural resources. The main directions in the waste management are the development of the construction of polygons and collecting system for non–hazardous municipal waste and the development of system for the collection and treatment of hazardous waste. At the moment 11 non-hazardous waste polygons and two polygons for hazardous waste got "A" category permits according to integrated pollution prevention and control (IPPC) directive. Biogas collection and use for energy production from biodegradable waste and sludge is set as one of waste management priorities in Latvia.

Main activity data sources for GHG emissions calculations in Waste sector are databases[236] "3-Waste", "2-Water" and data from CSB.

Data on hazardous waste in Latvia have been collected and compiled by LEGMC since 1997, but data on municipal (non-hazardous) waste since 2001. Until then the waste volume was determined on the basis of separate pilot projects and the assessments and projections by waste management experts.

Since 2002, databases about hazardous and municipal waste are combined in one database "3-Waste". Data in this database are gathered from State Statistical survey about waste, which is conducted annually.

Statistical survey must be completed annually by all enterprises, which have permits on polluting activities (A and B category) and all enterprises, which have permits on waste management operations. To estimate disposed waste amounts in preliminary years; data about population and Gross domestic product (GDP) are taken from CSB.

"2-Water" database was developed by LEGMC as well. Data of water abstraction and use, wastewater treatment and discharge have been collected since 1991 in the frame of state

[236] http://parissrv.lvgmc.lv/public_reports

statistical survey "2 – Water". State statistical survey "2-Water" must be reported by all enterprises which have issued permits on water use, water resources use or mineral deposits quarry use, or IPPC permit. Both LEGMC "2-Water" and CSB data are used as activity data for emission calculation - CSB and "2-Water" data for $CH_4$ emission from Domestic Waste Water Handling and Sewage Sludge, $N_2O$ emission from Industrial Waste Water Handling and NMVOC emission, and CSB for $CH_4$ emission from industrial waste water handling and $N_2O$ from Domestic Waste Water Handling.

## *7.2 SOLID WASTE DISPOSAL (CRF 5.A)*

### 7.2.1 Category description

Methane emission is calculated from SWD (Table 7.4). It is main GHG source from waste sector in Latvia. Compared to 2013, $CH_4$ emissions have increased by 1.18% in 2014. Compared to 1990 $CH_4$ emissions have increased by 4.17 kt due to First order decay calculation method.

**Table 7.4 Reported emissions under subcategory Solid Waste Disposal on Land**

| CRF | Source | Emissions reported |
|---|---|---|
| **5.A 1** | Managed Waste Disposal on Land | $CH_4$, NMVOC |
| **5.A 2** | Unmanaged Waste disposal Sites | $CH_4$, NMVOC |
| **5.A 3** | Uncategorized Waste disposal Sites | Not occurring |

To estimate $CH_4$ emissions with First Order Decay (Tier2) method from landfills, time series for disposed waste amounts till 1970 was developed. The base year for disposed amount estimation is 1996, when research[237] about biggest landfills was done. All calculations are done according to 1996 year amount. In that research total generated solid municipal waste amount is estimated as 2 379 829 $m^3$. It is assumed that outstanding part of these waste is going to landfills. Amount of disposed tons are calculated - 2 379 829 $m^3$ x 0.2 = 475 965 tons. Waste amounts 1997 – 2001 were estimated like equal growth between 1996 and 2002 amount. Amounts 1970 – 1995 were estimated according to GDP and population changes.

Value of waste density (0.2 $t/m^3$) is taken from Latvian Environment agency (2002) "Handbook in use of factors for inventory of municipal waste in transition from volume to a unit of weight"[238]

**Table 7.5 Estimated Disposed amounts from 1970 – 2002**

| Year | Population | Disposed solid waste amount (kt) | GDP/inhabitant (LVL - 2000 prices) | Disposed waste from urban areas (kt) | Disposed waste from rural areas (kt) |
|---|---|---|---|---|---|
| 1970 | **2351903** | 409.59 | 1230 | 249.95 | 159.65 |
| 1971 | 2368671 | 419.60 | 1286.4 | 260.15 | 159.45 |
| 1972 | 2385439 | 429.60 | 1342.8 | 266.35 | 163.25 |

[237] *"Research about solid waste management in Latvia", 1998, Ltd GEO Consultants*

[238] *http://www.lvgmc.lv/fs/CKFinderJava/userfiles/files/Vide/Atkritumi/statistika/Rokasgramata_atkr_faktori.pdf* .

| Year | Population | Disposed solid waste amount (kt) | GDP/inhabitant (LVL - 2000 prices) | Disposed waste from urban areas (kt) | Disposed waste from rural areas (kt) |
|---|---|---|---|---|---|
| 1973 | 2402207 | 439.61 | 1399.2 | 276.95 | 162.65 |
| 1974 | 2418975 | 449.61 | 1455.6 | 283.25 | 166.36 |
| 1975 | 2435744 | 459.62 | 1512 | 294.15 | 165.46 |
| 1976 | 2452512 | 469.62 | 1568.4 | 300.56 | 169.06 |
| 1977 | 2469280 | 479.62 | 1624.8 | 311.76 | 167.87 |
| 1978 | 2486048 | 489.63 | 1681.2 | 318.26 | 171.37 |
| 1979 | **2502816** | 499.63 | 1737.6 | 332.18 | 167.46 |
| 1980 | 2508728 | 508.59 | **1794** | 335.67 | 172.92 |
| 1981 | **2514640** | 517.55 | 1850.4 | 348.50 | 169.05 |
| 1982 | 2529255 | 527.35 | 1906.8 | 353.32 | 174.02 |
| 1983 | 2543870 | 537.15 | 1963.2 | 365.26 | 171.89 |
| 1984 | 2558486 | 546.94 | 2019.6 | 371.92 | 175.02 |
| 1985 | 2573101 | 556.74 | **2076** | 384.15 | 172.59 |
| 1986 | **2587716** | 572.04 | 2169.4 | 393.01 | 179.03 |
| 1987 | 2607822 | 587.87 | 2262.8 | 405.63 | 182.24 |
| 1988 | 2627928 | 603.70 | 2356.2 | 416.55 | 187.15 |
| 1989 | 2648034 | 619.53 | 2449.6 | 430.06 | 189.47 |
| 1990 | **2668140** | 635.36 | **2543** | 439.97 | 195.39 |
| 1991 | 2634628 | 599.65 | 2324.6 | 415.62 | 184.02 |
| 1992 | 2601116 | 563.93 | 2106.2 | 389.90 | 174.03 |
| 1993 | 2567604 | 528.22 | 1887.8 | 362.42 | 165.80 |
| 1994 | 2534092 | 492.50 | 1669.4 | 339.96 | 152.54 |
| 1995 | **2500580** | 456.79 | **1451** | 314.36 | 142.43 |
| **1996** | **2469531** | **475.96** | **1600** | 326.98 | 148.98 |
| 1997 | **2444912** | 506.30 | 1693.75 | 347.36 | 158.94 |
| 1998 | **2420789** | 536.64 | 1787.5 | 368.00 | 168.64 |
| 1999 | **2399248** | 566.98 | 1881.25 | 387.30 | 179.68 |
| 2000 | **2377383** | 597.32 | **1975** | 406.73 | 190.59 |
| 2001 | **2364254** | 627.66 | **2149** | 426.81 | 200.85 |
| 2002 | **2345768** | **658.00** | **2304** | | |

Figures in bold is primary data from National statistics[239] (Table 7.5). Waste amounts in all other years are estimated according to these figures. Disposed amount is estimated according to GDP and population changes. Population for 1971 -1978, 1982 – 1985, 1987 – 1988, 1991 – 1994 are calculated according to available amounts in nearest years. GDP data from 1970 – 1979 are estimated like the same decrease from 1985 - 1980.

Landfills from 1970 – 2001 are assumed as unmanaged[240]. Disposed amount are divided between rural and urban areas, according to proportion of population between these areas. Methane correction factors (MCF) for $CH_4$ emissions calculations in urban areas (deep sites - 0.8) and rural areas (shallow sites - 0.4) are used.

---

[239] *Statistical Yearbook of Latvia 2004, CSB, 2005*

[240] *"Degradable organic carbon in disposed waste", 2011, Ltd Virsma*

Data about waste disposal on land for 2002 - 2014 are taken from database "3-Waste" (Table 7.6). Starting from 2002, according to data base information, biggest sites could be assuemed as managed sites (polygons) and MCF-1 was started. For each year (2002-2014) in polygons disposed amount are determined according to disposing site profile from "3-Waste" data base.

**Table 7.6 Disposed solid waste amounts from 2002-2014 (kt)**

| Year | Total disposed solid waste amount | Disposed in polygons (MCF-1) | Disposed in deep unmanaged sites (urban area, MCF-0.8) | Disposed in shallow unmanaged sites (rural area, MCF-0.4) |
|---|---|---|---|---|
| 2002 | **658.0** | 217.46 | 303.97 | 136.57 |
| 2003 | **578.9** | 207.74 | 256.07 | 115.05 |
| 2004 | **631.7** | 282.84 | 240.71 | 108.15 |
| 2005 | **610.9** | 370.43 | 165.89 | 74.53 |
| 2006 | **670.0** | 454.39 | 148.78 | 66.84 |
| 2007 | **775.1** | 553.27 | 153.09 | 68.78 |
| 2008 | **704.8** | 566.89 | 95.12 | 42.74 |
| 2009 | **637.5** | 549.5 | 60.71 | 27.28 |
| 2010 | **605.4** | 586.9 | 12.73 | 5.72 |
| 2011 | **548.7** | 543.5 | 2.6 | 2.6 |
| 2012 | **529.5** | 525.568 | 1.98 | 1.98 |
| 2013 | **534.2** | 534.2 | 0 | 0 |
| 2014 | **520.274** | 520.274 | 0 | 0 |

According to information by landfill research, number of active waste disposal sites decreased from 558 in 1997 to 12 in 2014. All calculations are done for unsorted waste, because 95% of disposed waste is reported as unsorted.

According to the Latvia`s Waste management plan 2013 – 2020, in Latvia operates 11 waste disposing polygons, all other waste disposal sites are planned to close. In 2014 – 11 solid waste polygons are operating, all these sites are assumed as managed. Disposed solid waste amounts in Latvia are shown in Figure 7.4.

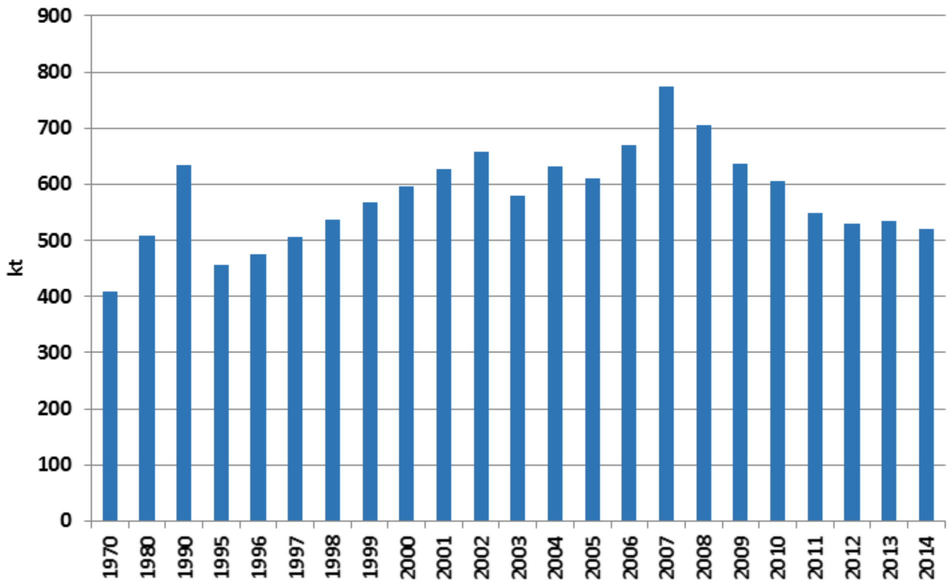


**Figure 7.4 Disposed waste amounts in Latvia (kt)**

Since October 2002, $CH_4$ recovery from landfills was started. For 2010 only in four waste facilities (*SIA Getlini EKO, SIA Liepajas RAS, SIA ZAAO Daibe, SIA Zemgale Eko*) $CH_4$ recovery was realized. In *SIA Getlini EKO* polygon methane was collected from old waste disposing area and from new waste disposing cells, which is specially built for waste disposing with biogas collection. In *SIA Liepajas RAS* methane collection also is developed in old landfill *Skede* and in new polygon *Kivites*. In *SIA ZAAO* polygon *Daibe* methane collection was started in the middle of 2009. In *SIA Zemgale Eko* polygon *Brakski* methane is started to collect in year 2013. In total 6.88 kt of $CH_4$ was collected and recovered in 2014. Recovered methane amount is presented in Figure 7.5.

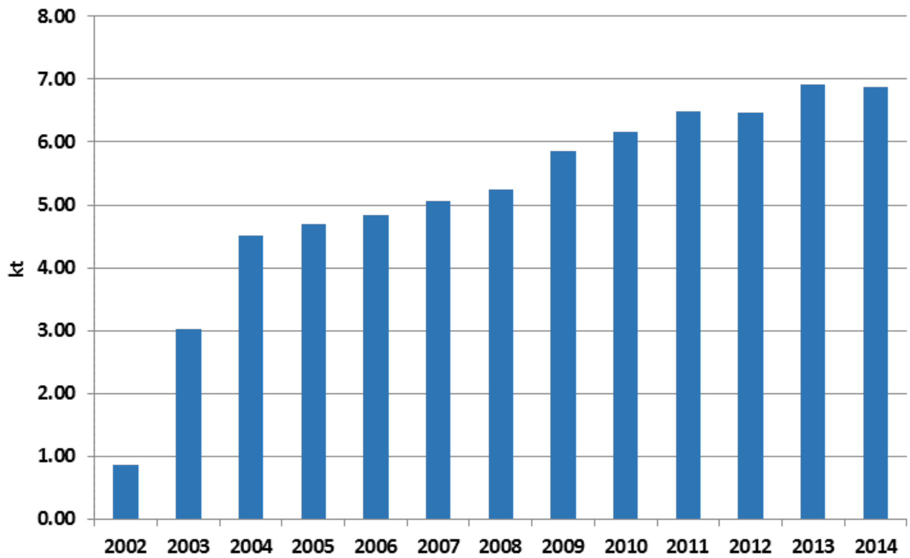


**Figure 7.5 Recovered $CH_4$ from waste disposing (kt)**

According to the Latvia's Waste Management plan 2013-2020, $CH_4$ recovery from landfills is one of priorities in waste management. $CH_4$ emission from waste disposing in SWD sites is presented in Figure 7.6.

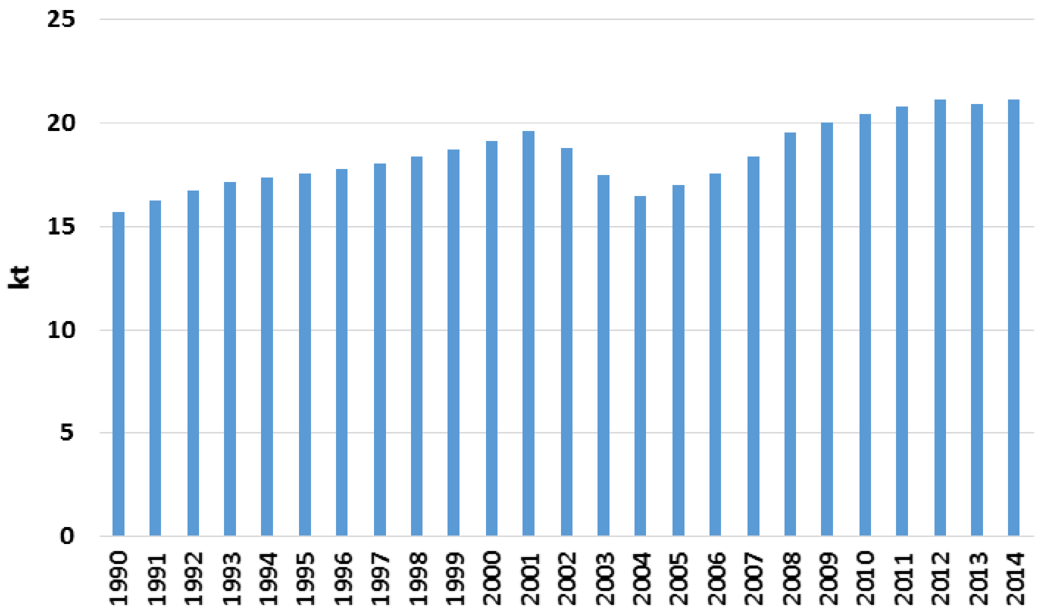


**Figure 7.6 $CH_4$ emissions from waste disposing (kt)**

### 7.2.2 Methodological issues

Tier 2 method from 2006 IPCC Guidelines is used for $CH_4$ emissions calculation and is based on IPCC Waste Model.

**Emission factors used in IPCC Waste Model:**

MCF – $CH_4$ correction factor, depend of waste disposal site type
Managed sites – 1
Deep unmanaged sites - 0.8
Shallow unmanaged sites - 0.4

DOC – degradable organic carbon (0.17)
DOCf – fraction of DOC dissimilated (0.5)
F – fraction of CH4 landfill gas (0.5)
k- methane generation rate (0.09)
OX – oxidation factor (default 0)

Fraction of $CH_4$ in landfill gas is estimated as 0.5 according to information, which is received from methane collection enterprises. Methane collection enterprises provide information about collected methane amount and also about methane concentration in landfill gas. Methane concentration is mutable, it diversifies from 0.47 – 0.54 depending on time frame and weather conditions.

DOC value 0.17 is used according to research which was carried out in Latvia in 2011 ("Degradable organic carbon in disposed waste", 2011, Ltd Virsma). Other emission factors are default from 2006 IPCC Guidelines.

### 7.2.3 Uncertainties and times-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

To calculate $CH_4$ emissions from SWD many emission factors are used. According to 2006 IPCC Guidelines for each factor uncertainty is estimated as:

DOC – 20%;

DOCf – 30%;

MCF – 10%;

$CH_4$ fraction F – 5%;

k – 40%.

$$EF_{uncert.} = \sqrt{DOC^2 + DOCf^2 + MCF^2 + F^2 + k^2}$$

Combined uncertainty for emission factors from SWD is 52%.

Uncertainty for activity data is estimated as 7%.

Uncertainty assessment of activity data is done using the proportion between disposed amount and population (2002-2014). Uncertainty is calculated as the standard medium of the average from linear trend line.

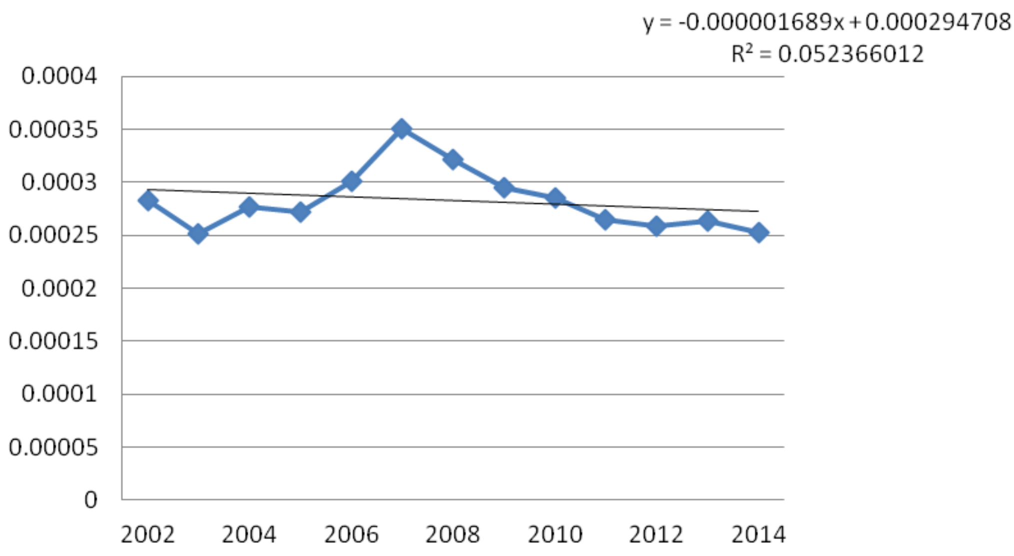


**Figure 7.7 Trendline and proportion waste-to-population for waste disposal**

### 7.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the waste sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

Disposed waste amount since 2002 is taken from waste data base "3-Waste". Data in this data base are checked and approved by Regional Environmental Boards.

National factor of DOC is determined in national research "Degradable organic carbon in disposed waste", 2011, Ltd Virsma. Distribution between managed and unmanaged sites is also described in this research which is available in QA/QC documentation.

Information regarding $CH_4$ recovery is taken directly from waste polygon reports. These reports are collected and checked by LEGMC every year. Latvia's waste polygon report is published in LEGMC website every year. Information about distribution between flaring and energy recovery is described. In Latvia`s case it is impossible to correctly estimate distribution of $CH_4$ recovery between managed and unmanaged sites, because old landfill and new disposing cell are located in one site. Collected $CH_4$ is counted together, but that does not affect final $CH_4$ emissions.

### 7.2.5 Category-specific recalculation

No recalculations are done.

### 7.2.6 Category-specific planned improvements

Estimation of MCF will be done for Latvia landfills for all time series. It is planned to make an efforts within the programme "European Economic Area Financial Mechanism 2009-2014 "National Climate Policy" to improve MCF. Improvement will be undertaken for the next submission.

## *7.3 BIOLOGICAL TREATMENT AND SOLID WASTE (CRF 5.B)*

### 7.3.1 Composting (CRF 5.B.1)

#### 7.3.1.1 Category description

Under 5.B.1 sector $CH_4$ and $N_2O$ emissions from waste composting are calculated. Composting is set as one of priorities in waste treatment in Latvia. For composting biological degradable waste are useful. In Latvia these are mostly "park - garden" and "food production" waste.

Data about industrial composting become available since 2003, when waste treatment companies started waste composting and get IPPC permits on this activity.

Composting in private households has been very popular for many years. Composted waste amount in households is estimated according to research[241] done by Waste Management

[241] *"Composting emission factor development from waste and waste water sectors and methane correction factor estimation for Latvia landfills", 2015, Waste Management Association of Latvia*

Association of Latvia in 2015. In this research total amount of composted waste in households are estimated for 2012 – 2014. Time series are extrapolated back to 1990 according to changes in population number.

**Table 7.7 Reported emissions under composting**

| CRF | Source | Emissions reported |
|---|---|---|
| **5.B.1.** | Compost production | $CH_4$, $N_2O$ |

From composting $CH_4$ and $N_2O$ emissions are calculated according to 2006 IPCC Guidelines. In previous IPCC Guidelines emission factors for composting were not provided. Data regarding composted waste are taken from "3-Waste" database. In 2011 there was an increase of composted amounts in composting enterprises.

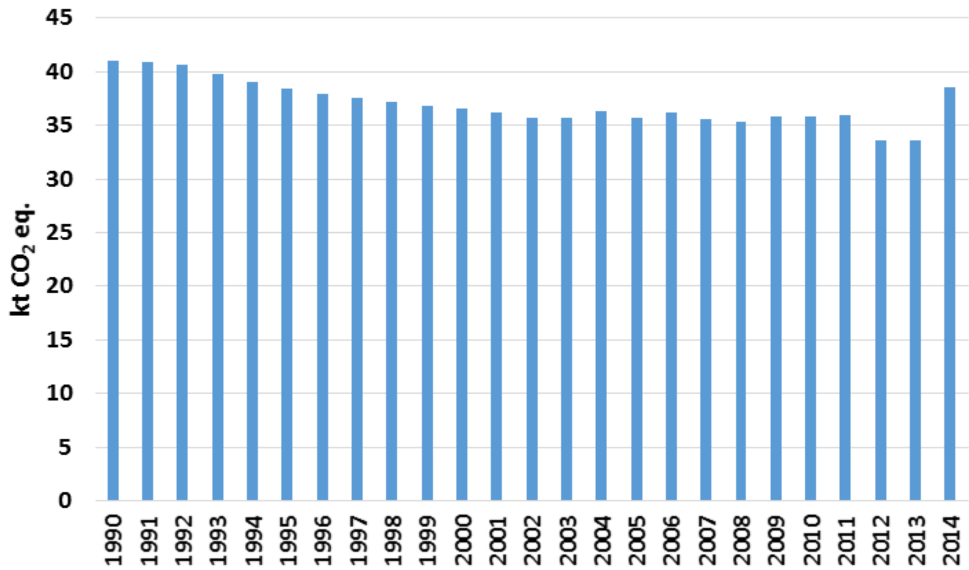


**Figure 7.8 Total emissions from waste composting (kt $CO_2$ eq.)**

### 7.3.1.2 Methodological issues

Default method from 2006 IPCC Guidelines is used for emission calculations from composting. Composted waste amount is multiplied with default emission factor. Composted waste amount is taken from "3-Waste" database, R3 - Recycling/reclamation of organic substances that are not used as solvents (including composting and other biological transformation processes), recovery operation for determination of composted amounts was used. Not all amounts, which are classified under recovery as R3, are composted. To determine composted waste amount, each enterprise, which reports recovery operations R3, working profile must be taken into account.

Default emission factors for composting were used from 2006 IPCC Guidelines:

Industrial composting:

1. 4 g $CH_4$/ kg composted waste;
2. 0.24 g $N_2O$/ kg composted waste.

**Table 7.8 Composted waste amounts and emissions (kt)**

| Year | Composted amounts in households (kt) | Industrial composted amount (kt) | $CH_4$ emission (kt) | $N_2O$ emission (kt) |
|---|---|---|---|---|
| 1990 | 239.0918253 | - | 0.956367301 | 0.057382 |
| 1991 | 238.1976078 | - | 0.952790431 | 0.0571674 |
| 1992 | 236.8390317 | - | 0.947356127 | 0.0568414 |
| 1993 | 231.7021428 | - | 0.926808571 | 0.0556085 |
| 1994 | 227.6902168 | - | 0.910760867 | 0.0546457 |
| 1995 | 224.0767862 | - | 0.896307145 | 0.0537784 |
| 1996 | 221.2944877 | - | 0.885177951 | 0.0531107 |
| 1997 | 219.0883809 | - | 0.876353524 | 0.0525812 |
| 1998 | 216.9267207 | - | 0.867706883 | 0.0520624 |
| 1999 | 214.9964333 | - | 0.859985733 | 0.0515991 |
| 2000 | 213.4253025 | - | 0.85370121 | 0.0512221 |
| 2001 | 210.8865637 | - | 0.843546255 | 0.0506128 |
| 2002 | 207.9806931 | - | 0.831922772 | 0.0499154 |
| 2003 | 206.0481654 | 2.224 | 0.833088662 | 0.0499853 |
| 2004 | 203.9987864 | 7.905 | 0.847615146 | 0.0508569 |
| 2005 | 201.5975989 | 6.564 | 0.832646396 | 0.0499588 |
| 2006 | 199.639622 | 11.698 | 0.845350488 | 0.050721 |
| 2007 | 197.9339867 | 9.416 | 0.829399947 | 0.049764 |
| 2008 | 196.4079297 | 9.282 | 0.822759719 | 0.0493656 |
| 2009 | 193.8113925 | 15.11 | 0.83568557 | 0.0501411 |
| 2010 | 190.0182044 | 18.55 | 0.834272818 | 0.0500564 |
| 2011 | 185.9051984 | 23.699 | 0.838416794 | 0.050305 |
| 2012 | 178.157 | 17.62 | 0.783108 | 0.0469865 |
| 2013 | 181.3548064 | 14.367 | 0.782887226 | 0.0469732 |
| 2014 | 184.614 | 40.038 | 0.898608 | 0.0539165 |

#### 7.3.1.3 Uncertainties and times-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Emission factor uncertainties are calculated according range, which is published in 2006 IPCC Guidelines, Volume 5, Chapter 4, For $N_2O$ range is 0.06 – 0.6, for $CH_4$ 0.03 – 8, Uncertainty for $N_2O$ emission factor is 90%, for $CH_4$ – 100%.

Time series for composting begins in 1990.

Uncertainty for households composted amounts are assumed as the same as for industrial composting.

Activity data uncertainty for industrial composting is estimated as 29%.

Uncertainty assessment of activity data for industrial composting is done using the proportion between composted amount and population (2004-2014). Uncertainty is calculated as the standard medium of the average from linear trend line.

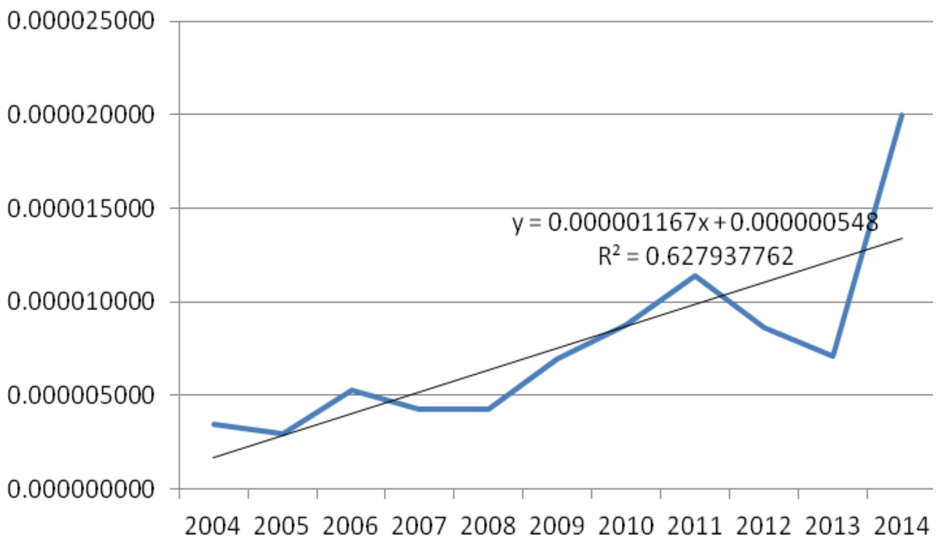


**Figure 7.9 Trendline and proportion waste-to-population for waste composting**

#### 7.3.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the waste sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

Industrial composted waste amounts are taken from from "3-Waste" data base. Data in this data bases are checked and approved by Regional Environmental Boards.

#### 7.3.1.5 Category-specific recalculations

For the first time composting emissions from households are calculated.

#### 7.3.1.6 Category-specific planned improvements

New waste recovery classification in Latvia came into force in 2014. Determination of composting amounts will be more precise, because special R code will be used for composting.

### 7.3.2 Anaerobic Digestion at Biogas Facilities (CRF 5.B.2)

Anaerobic Digestion at biogas facilities is carried out in Latvia. All emissions are allocated under Energy sector because all biogas is used for energy production.

## *7.4 INCINERATION AND OPEN BURNING OF WASTE (CRF 5.C)*

### 7.4.1 Waste Incineration (CRF 5.C.1)

#### 7.4.1.1 Category description

Data on amount of waste incinerated in Latvia can be found in databases that are created and maintained by LEGMC. Data on hazardous waste incineration are available since 1999. In the hazardous waste data base there is a separate entry for 1997-2001 on the amount of incinerated waste. Since 2002 the database also contains entries for recovery (R) and disposal (D) of waste, which is consistent with the EU Waste legislation.

**Table 7.9 Reported emissions under category Waste Incineration**

| CRF | Source | Emissions reported |
|---|---|---|
| **5.C 1** | Biogenic (cremation) | $SO_2$, NMVOC, CO, NOx |
| **5.C 2** | Other – non biogenic (clinical (animal) and hazardous (industrial) waste) | $CO_2$, $N_2O$, $SO_2$, NMVOC, CO, NOx |

Currently there are no large amounts of waste being incinerated in Latvia without energy recovery. The main source of emissions refer to the hazardous and clinical waste incineration. The amounts of incinerated clinical waste are registered in the hazardous waste database (from 2002 in "3-Waste" data base) as *Health service for humans and animals as well as related research waste*. Amount of incenerated animal waste (dead animals) are assumed as Clinical waste. The rest of the incinerated waste from hazardous waste database is considered as hazardous (industrial) waste.

In 2001 large increase of emissions can be observed, because one enterprise reported huge amount of incinerated waste. Incinerated amounts for 1990 – 1998 are extrapolated according to average value of incinerated amount for 2002 – 2013 which refers to disposed waste value.

In latest years incinerated amount of waste has decreased due the reason that hazardous waste incineration is not occuring in full scale. $CO_2$ emissions from Waste Incineration are presented in Figure 7.10.

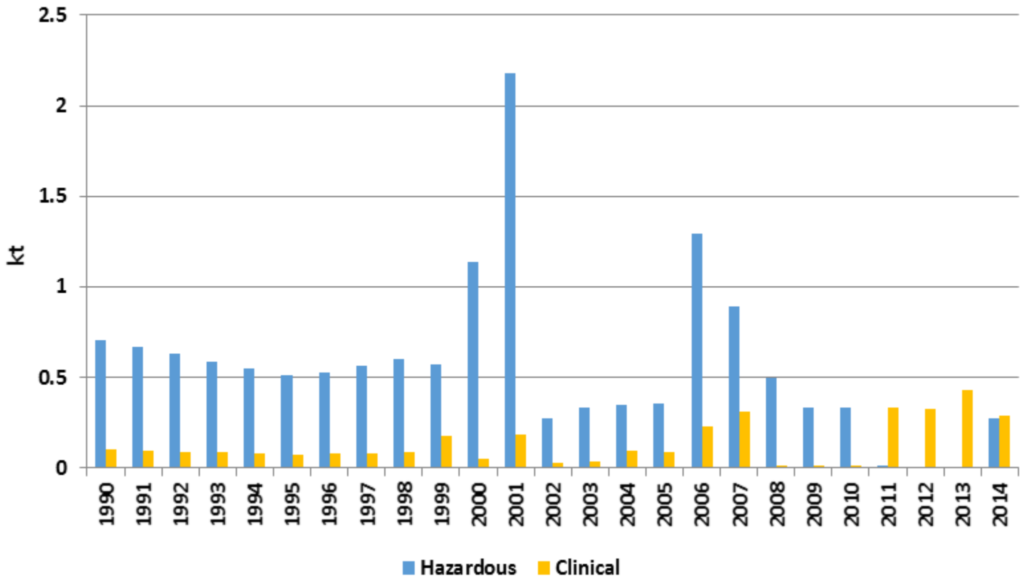


**Figure 7.10 $CO_2$ emissions from Waste Incineration by waste type (kt)**

Data about burned bodies is available from Riga crematorium since 1994. Calculations of emissions are done in accordance with the EMEP/EEA 2013 methodology. The main gases emitted during cremation are $SO_x$, $NO_x$, CO, and NMVOC, and all of them have to be reported in the inventory as indirect GHGs. These amounts are counted in Incinerated Biogenic Waste sector (Table 7.10).

**Table 7.10 Burned bodies in Riga crematorium**

| Year | Burned bodies |
|---|---|
| 1994 | 54 |
| 1995 | 564 |
| 1996 | 819 |
| 1997 | 817 |
| 1998 | 869 |
| 1999 | 982 |
| 2000 | 1127 |
| 2001 | 1297 |
| 2002 | 1293 |
| 2003 | 1389 |
| 2004 | 1391 |
| 2005 | 1529 |
| 2006 | 1630 |
| 2007 | 1959 |
| 2008 | 2227 |
| 2009 | 1977 |
| 2010 | 2102 |
| 2011 | 2158 |
| 2012 | 1970 |
| 2013 | 2150 |
| 2014 | 2222 |

#### 7.4.1.2 Methodological issues

According to the 2006 IPCC Guidelines $CO_2$ and $N_2O$ emissions are calculated from the Waste Incineration. $CH_4$ emissions in well-functioning incinerators are usually very small. The $CH_4$ emissions are particularly relevant for open burning. Usually $CO_2$ emissions are substantially larger than emissions of $N_2O$. Emissions from waste incineration without energy production are considered under the Waste sector, while emissions from waste incineration with energy production are considered under the Energy sector (CRF 1.A.2.f Non-metalic minerals).

$CO_2$ emissions were calculated using following 2006 IPCC Guidelines equation:

$$CO_{2\ emissions} = \Sigma_i[SW_{ix} \times CF_i \times FCF_i \times OX_i \times 44/12]\ kt/year$$

*where:*
*i = waste type (hazardous waste, clinical waste)*
*$SW_i$ = amounts of type i waste incinerated. (kt/year)*
*$CF_i$ = carbon contents in the type i waste*
*$FCF_i$ = fossil carbon contents in the type i waste*
*$OX_i$ = oxidation factor of type i waste*
*44/12 = conversion of C into $CO_2$*

There are no national factors for carbon and fossil carbon amounts in each type of waste; therefore default emission factors from 2006 IPCC Guidelines were used (Table 7.11).

**Table 7.11 Default emission factors for $CO_2$ emission calculation**

| | Clinical (animal) waste | Hazardous (industrial) waste |
|---|---|---|
| **C contents in waste (CCW)** | 0.6 | 0.5 |
| **Fossil C contents in waste (FCF)** | 0.4 | 0.9 |
| **Oxidation factor (OX)** | 100% | 100% |

$N_2O$ emissions from Waste incineration are calculated according to 2006 IPCC Guidelines, Volume 5 Table 5.6. Factor 100 (g $N_2O$/ t waste) is used. This factor is determined for Industrial waste in wet weight. Latvia's incinerated hazardous waste are used oils, solvents and other liquids. Clinical waste is not dried before burning. The same factor also is used for $N_2O$ emission calculation from clinical waste.

**Table 7.12 Incinerated waste amounts without energy recovery**

| Year | Hazardous waste (kt) | Clinical waste (kt) | Animal waste (kt) | Total (kt) |
|---|---|---|---|---|
| **1990** | 0.429082 | 0.116729 | - | 0.545812 |
| **1991** | 0.404964 | 0.110168 | - | 0.515131 |
| **1992** | 0.380845 | 0.103606 | - | 0.484451 |
| **1993** | 0.356726 | 0.097045 | - | 0.453771 |
| **1994** | 0.332607 | 0.090484 | - | 0.423091 |
| **1995** | 0.308488 | 0.083922 | - | 0.39241 |
| **1996** | 0.321434 | 0.087444 | - | 0.408878 |
| **1997** | 0.341924 | 0.093018 | - | 0.434942 |
| **1998** | 0.362414 | 0.098592 | - | 0.461006 |
| **1999** | 0.34721 | 0.20142 | - | 0.54863 |
| **2000** | 0.69028 | 0.05641 | - | 0.74669 |
| **2001** | 1.31927 | 0.21331 | - | 1.53258 |
| **2002** | 0.165643 | 0.032247 | - | 0.19789 |
| **2003** | 0.201813 | 0.040607 | - | 0.24242 |
| **2004** | 0.210125 | 0.112325 | - | 0.32245 |
| **2005** | 0.215127 | 0.102127 | - | 0.317254 |
| **2006** | 0.78616 | 0.26189 | - | 1.04805 |
| **2007** | 0.5405 | 0.350861 | - | 0.891361 |
| **2008** | 0.29975 | 0.012361 | - | 0.312111 |
| **2009** | 0.200 | 0.011663 | - | 0.211663 |
| **2010** | 0.200 | 0.012843 | - | 0.212843 |
| **2011** | 0.0063 | 0.012738 | 0.366092 | 0.38513 |
| **2012** | NO | 0.018049 | 0.348861 | 0.36691 |
| **2013** | NO | 0.005887 | 0.479833 | 0.48572 |
| **2014** | 0.166927 | 0.010341 | 0.3166033 | 0.493301 |

Indirect GHGs (NMVOC, CO, $SO_2$, NOx) are calculated from waste incineration according to EMEP/EEA 2013 (Table 7.13).

**Table 7.13 Emission factors for indirect GHGs**

| | Clinical waste (kg/Mg) | Hazardous waste (kg/Mg) |
|---|---|---|
| NMVOC | 0.7 | 7.4 |
| CO | 0.19 | 0.07 |
| $SO_2$ | 0.24 | 0.047 |
| NOx | 2.3 | 0.87 |

**Cremation**

Indirect GHG emissions from cremation were calculated by multiplying the number of bodies burned with the corresponding emission factor. Calculations were based on emission factors given in the EMEP/EEA 2013 (Table 7.14).

**Table 7.14 Emission factors for indirect GHGs from cremation**

| Indirect GHG | Emission factor (kg/body) |
|---|---|
| NMVOC | 0.013 |
| CO | 0.140 |
| $SO_2$ | 0.113 |
| NOx | 0.825 |

#### 7.4.1.3 Uncertainties and times-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

$CO_2$ emission factor uncertainty is estimated as 40%, according 2006 IPCC Guidelines, because no correct information on carbon content in incinerated waste is known. Uncertainty for $N_2O$ emission factor is 100%.

Activity data uncertainty for waste incineration is estimated as 44%.

Uncertainty assessment of activity data for waste incineration is done using the proportion between incinerated amount and population (years 2002-2014). Uncertainty is calculated as the standard medium of the average from linear trend line.

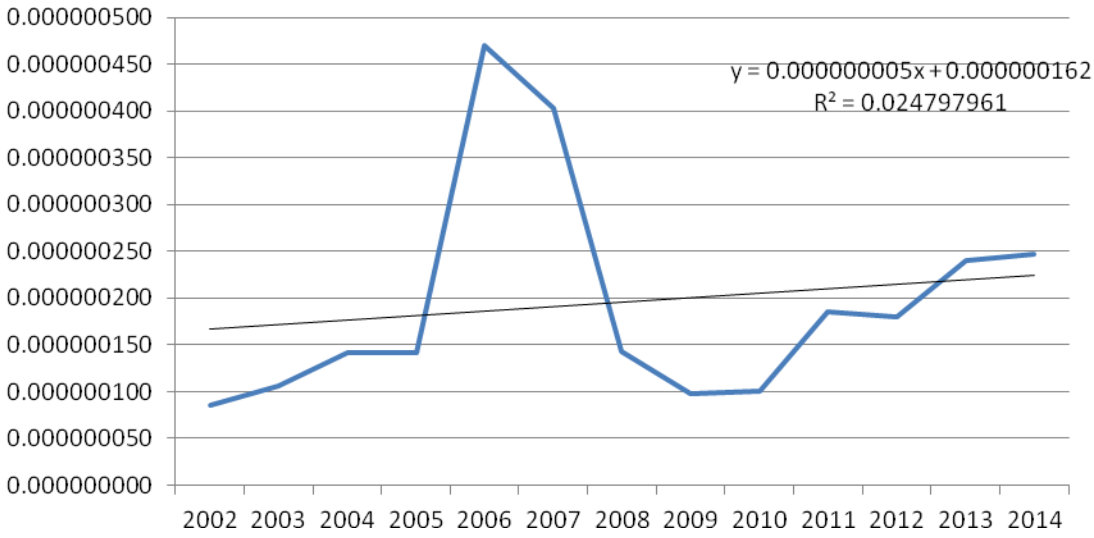


**Figure 7.11 Trendline and proportion waste-to-population for waste incineration**

#### 7.4.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the waste sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

QA/QC procedures for waste incineration are done. Incinerated waste amounts are taken from "3-Waste" data base. Data in this data bases are checked and approved by Regional Environmental Boards.

#### 7.4.1.5 Category-specific recalculations

No recalculations are done.

#### 7.4.1.6 Category-specific planned improvements

No planned improvements.

### 7.4.2 Open Burning of Waste (CRF 5.C.2)

Open burning of waste is reported as NO (Not occuring). Open burning is not allowed in Latvia according to Waste Management Law.

## *7.5 WASTEWATER TREATMENT AND DISCHARGE (CRF 5.D)*

### 7.5.1 Domestic Wastewater (CRF 5.D.1)

#### 7.5.1.1 Category description

The emission sources cover handling of collected and uncollected domestic waste water for $CH_4$ from both waste water and sewage sludge and $N_2O$ emissions from human sewage.

In most cases urban waste water is treated in aerobic systems in Latvia. However, the accurate breakdown of amount aerobic and anaerobic processes during treatment of municipal waste water is unknown.

Therefore, data on type of treatment plant and its treatment level is available within national database "2-Water", and all the treatment plants and number of population they serve is distributed by their type and level of treatment.

Totally, taking into account of recovered $CH_4$ as well, emissions from Domestic Waste Water Handling sector made 126.0 kt $CO_2$ eq. in 2014, what makes decrease of 45.8% in comparison to 1990 and decrease of 4.1% in comparison to emissions of 2013 (Figure 7.12).

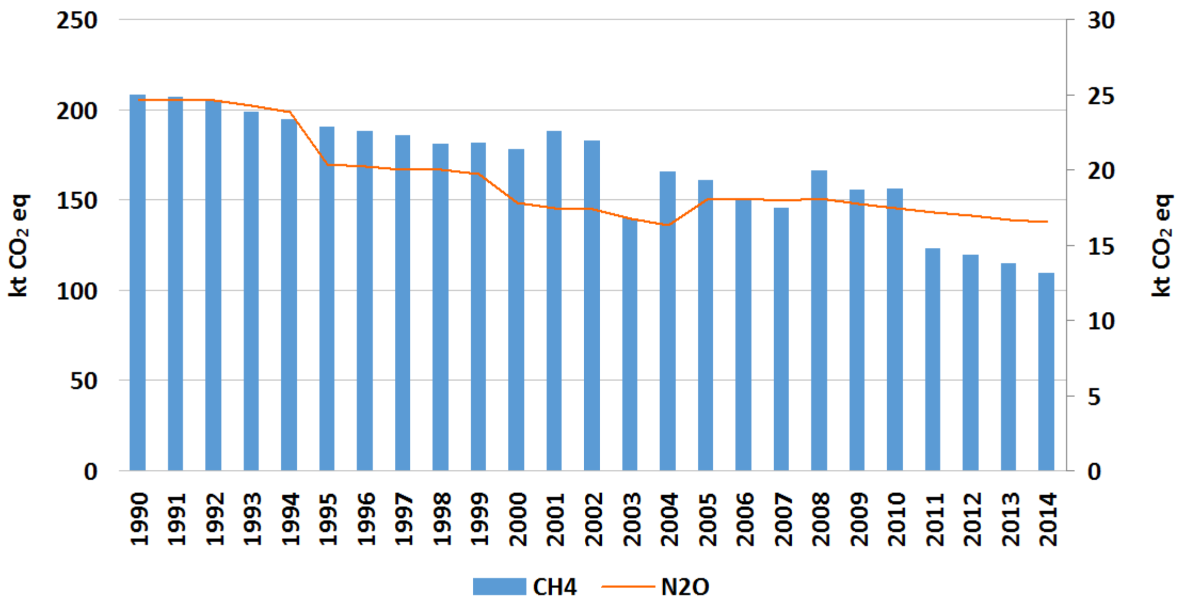


**Figure 7.12 Emissions from Domestic Waste Water Handling sector[242] (kt $CO_2$ eq.)**

### 7.5.1.2 Methodological issues

Calculation of $CH_4$ emission from Domestic Waste Water Handling is based on amount of $BOD_5$ (biochemical oxygen demand, 5-day test) produced by national population. However, different methane conversion factors (MCFs) are applied depending of type and level of treatment of certain treatment plant. Data on treatment type and level of certain waste water treatment plant serving certain number of population is available in national data base "2-Water"[243], collecting treatment plant-level data on water abstraction and use, treatment and discharge. Distribution of national population by type and level of waste water treatment was extrapolated for period, uncovered by water statistics (1990-1999).

Default formula from 2006 IPCC Guidelines, chapter 6.2.2 „Domestic Wastewater" was used for calculation of $CH_4$ emission from Domestic Waste Water Handling sector. However, distribution of national population by treatment type and level is used instead of distribution of national population by income level.

$$CH_4 Emissions = \left[ \sum_i (U_i \bullet EF_i) \right] \bullet (TOW - S) - R$$

*where*
*$CH_4$Emissions – $CH_4$ emissions in the inventory year, kg $CH_4$/yr*
*TOW – total organics in waste water in inventory year, kg BOD/yr*
*S – organic component removed as sludge in inventory year, kg BOD/yr*
*$U_i$ – degree of national population receiving certain waste water treatment type and level, %*
*i –waste water treatment type and level (well-managed biological, poor-managed biological, non-biological and no collection and no treatment)*
*EFi – emission factor for each treatment type fraction, kg $CH_4$/kg BOD*

[242] *$N_2O$ on secundary axis*
[243] *http://parissrv.lvgmc.lv/public_reports/#viewType=water2reports*

*R – amount of $CH_4$ recovered in inventory year, kg $CH_4$/yr*

$$EF_i = B_o \bullet MCF_i$$

*where:*
*EFi – emission factor for each treatment type fraction, kg $CH_4$/kg BOD*
*i –waste water treatment type and level (well-managed biological, poor-managed biological, non-biological and no collection and no treatment)*
*$B_o$ – maximum $CH_4$ producing capacity, kg $CH_4$/kg BOD*
*$MCF_i$ – methane correction factor for each treatment type and level*

$$TOW = P \bullet BOD * 0.001 \bullet I \bullet 365$$

*where*
*TOW – total organics in waste water in inventory year, kg BOD/yr*
*P – country population in inventory year, persons*
*BOD – country-specific per capita BOD in inventory year, g/person/day*
*I – correction factor for additional industrial BOD discharged into sewers*

$CH_4$ emissions from anaerobic sewage sludge were calculated using default formula from „Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual"; chapter 6.3.5 „Methodology for Estimating Emissions from Wastewater Handling". In this case IPCC 1996 were used because 2006 IPCC Guidelines do not provide methodology to estimate emissions from anaerobic sewage sludge.

$$SM = TOS \bullet EF$$

*where:*
*SM – total $CH_4$ emission from sewage sludge, kg $CH_4$*
*TOS – total organic content of sludge, kg COD/yr*
*EF – emission factor for sludge, kg $CH_4$/kg COD*

$$EF = B_o \bullet MCF$$

*where:*
*EF – emission factor for anaerobic sewage sludge, kg $CH_4$/kg COD*
*Bo – maximum $CH_4$ producing capacity, kg $CH_4$/kg COD*
*MCF – methane correction factor*

Methane Conversion Factors (MCFs) were applied depending of treatment type and level. 2006 IPCC Guidelines were used as source of MCF values; however, expert judgment was performed to choose values applicable for Latvian conditions (Table 7.15).

**Table 7.15 MCF values applied depending on type and level of treatment**

| Treatment type and level | MCF |
|---|---|
| Biological treatment with secondary or higher treatment level | 0 |
| Biological treatment with treatment level lower than secondary | 0.3 |
| Mechanical and chemical treatment | 0.3 |
| Not connected to waste water treatment plants | 0.5 (septic tanks)<br>0.7 (latrines) |

Although normally mechanical and chemical treatment is not a source of methane emissions, there are still rather large number of mechanical treatment plants in Latvia, where domestic waste water is treated; therefore it is considered that conditions in the mechanical treatment plants similar to those in the poorly managed biological treatment plants and, as result, the same value of MCF is applied. It was agreed as well in the discussion with Technical Expert Review Team (TERT) during the EU ESD voluntary review in 2015.

Typical mechanical and/or chemical treatment plants in Latvia mostly serves specific industrial waste water flows, where number of population connected and served is low or not at all, so this assumption does not affect calculations of emissions from human produced organic products in the waste water.

Organic load – so called "population equivalent" or 60 g of BOD per person per day – is determined by national legislation (Cabinet Regulation No. 34 "Regulations regarding Discharge of Polluting Substances into Water" (22.01.2002)).

Activity data, used for calculation of $CH_4$ emissions from domestic waste water are summarized in the following Table 7.16.

**Table 7.16 Activity data for calculation $CH_4$ emissions from Domestic Waste Water Handling sector**

| Year | Population receiving well-managed biological treatment | Population receiving poor-managed biological treatment | Population receiving non-biological treatment | Population receiving no treatment | Amount of anaerobic sludge, t/y (dry solids) | Amount of recovered $CH_4$, kt/y |
|---|---|---|---|---|---|---|
| 1990 | 1 459 034 | 410 363 | 69 301 | 729 442 | 9 029 | 0 |
| 1995 | 1 367 407 | 384 592 | 64 949 | 683 633 | 6 424 | 0.344 |
| 2000 | 1 300 038 | 366 587 | 61 524 | 649 234 | 4 559 | 0.764 |
| 2001 | 1 270 656 | 279 768 | 48 911 | 754 049 | 5 788 | 0.948 |
| 2002 | 1 289 321 | 278 673 | 49 642 | 703 320 | 5 367 | 1.252 |
| 2003 | 1 575 982 | 95 457 | 44 481 | 583 470 | 6 416 | 0.801 |
| 2004 | 1 467 919 | 76 138 | 44 931 | 687 532 | 9 569 | 1.453 |
| 2005 | 1 448 202 | 81 977 | 45 164 | 674 381 | 8 479 | 1.683 |
| 2006 | 1 442 124 | 89 970 | 44 086 | 651 694 | 6 337 | 1.423 |
| 2007 | 1 454 319 | 76 998 | 40 059 | 637 464 | 5 853 | 1.489 |
| 2008 | 1 234 969 | 168 147 | 37 556 | 751 138 | 2 761 | 1.469 |
| 2009 | 1 362 273 | 125 021 | 20 145 | 655 395 | 7 019 | 1.860 |
| 2010 | 1 263 185 | 141 101 | 29 430 | 686 788 | 4 277 | 2.133 |
| 2011 | 1 464 581 | 91 294 | 26 178 | 488 318 | 6 914 | 1.870 |
| 2012 | 1 406 665 | 106 529 | 32 942 | 498 677 | 4 186 | 1.957 |
| 2013 | 1 417 448 | 94 034 | 28 559 | 483 784 | 4 275 | 1.806 |
| 2014 | 1 460 824 | 50 607 | 23 502 | 466 535 | 5 381 | 1.704 |

Some assumptions are made to calculate emissions from domestic waste water handling:

- Total organically degradable carbon, removed from domestic waste water with sludge, is divided proportionally between types of treatment. Type of treatment "not connected" removes no carbon in sludge.
- Only temporal storage of sewage sludge with dry solid content less then 20% could be considered as anaerobic conditions, since all other ways or conditions of sewage sludge (for example, storage after dewatering procedures, what results in content of dry solids 20% and more) does not allow to use MCF value for "deep anaerobic lagoons", as it was recommended by TERT during 2015 trial review under the EU ESD,

especially, if dewatered sewage sludge is being stored in the piles. An expert judgment was performed and documented to establish the 20% solid content threshold value to divide sudge in anaerobic/aerobic [244].

**Figure 7.13 Dewatered sewage sludge storage shed. Considered to be no source of $CH_4$ emissions**

**Figure 7.14 Liquid sewage sludge storage basin. Considered to be source of $CH_4$ emissions (deep anaerobic lagoon)**

[244] *Expert judgment protocol EJ_Waste_5D_2016_001*

Example of methane emission calculation for 2014 is shown in a following Table 7.17.

**Table 7.17 Calculation of $CH_4$ emission from Domestic Waste Water Handling sector (2014)**

| Treatment type | Population persons | Total DC (kt BOD/yr) | DC WW w/o sludge (kt BOD/yr) | Correction factor for additional industrial discharges of BOD into a sewer | Maximum $CH_4$ producing capacity $B_o$, kg $CH_4$/kg BOD | MCF | Emission factor | Emission (kt of $CH_4$) |
|---|---|---|---|---|---|---|---|---|
| Well managed biological | 1 460 824 | 31.992 | 28.644 | 1.25 | 0.6 | 0 | 0 | 0 |
| Poor managed biological | 50 607 | 1.108 | 0.993 | 1.25 | 0.6 | 0.3 | 0.18 | 0.223 |
| Non-biological | 23 502 | 0.515 | 0.461 | 1.25 | 0.6 | 0.3 | 0.18 | 0.104 |
| Not connected to treatment plants | 466 535 | 10.217 | 10.217 | 1 | | | | |
| Total: | 2 001 468 | 43.832 | 4.335 | | | | | **0.327** |

Assumptions regarding sewage sludge are shown in Table 7.18.

**Table 7.18 Characteristics of sewage sludge in Latvia**

| Characteristic | Value |
|---|---|
| Average content of dry solids in sludge, %[245] | 14[246] |
| Average content of COD in dry solids, % | 65[247] |
| Average content of N in dry solids, % | 5.2[248] |

Extrapolation was used to estimate amount of sewage sludge produced and treated anaerobically for period 1990 – 1997, where statistic data were not available. Based on statistics available (1998 – 2008), assumption was made the part of anaerobically stored sludge is 25% of all sludge produced. Emissions from sludge, used as fertilizer in agriculture or disposed in landfills, are reported under according sectors in different chapters of this NIR.

Data on recovery of $CH_4$ from waste water handling are plant specific data from treatment plant *"Daugavgrīva"*, operated by largest Latvian water supply and waste water Treatment Company *"Rīgas ūdens"*. Recovery of $CH_4$ is also performed by its daughter company *"Rigens"*, starting from 2002. 1.704 kt of $CH_4$ was recovered from waste water handling in 2014. Recovered amount of $CH_4$ is being used as fuel in the cogeneration plant, and emissions from it are reported under the Energy sector. It is assumed, that content of the $CH_4$ in the recovered biogas by volume is 70%, and density of $CH_4$ is 0.6687 kg/m$^3$.

245 *Is used to estimate content of dry solids for years where statistic data are not available (1998-2002)*
246 *"Notekūdeņu dūņas un to izmantošana" („Sewage Sludge and Disposal of it"), Gemste I., Vucāns A., Jelgava, 2002.*
247 *Average data of 1996*
248 *"Notekūdeņu dūņas" ("Sewage Sludge"), Gemste I., Vucāns A., Jelgava, 2007.*

According to 2006 IPCC Guidelines, there are emissions of recovered $CH_4$ in the form of leakage from the recovery. Default value of 5% of leakage was used to estimate amount of $CH_4$ emissions of this source, thus giving emission of 5% of 1.704 kt $CH_4$ = 0.085 kt $CH_4$ in 2014.

Example of $CH_4$ emission calculation from sewage sludge is shown in Table 7.19.

**Table 7.19 Calculation of $CH_4$ emission from sewage sludge (2014)**

| Total DC sludge (kt COD/yr) | Maximum $CH_4$ producing capacity Bo, kg $CH_4$/kg COD | MCF for deep anaerobic lagoons | Emission factor for sludge (kg $CH_4$/ kg COD) | Emission of sludge (kt $CH_4$) |
|---|---|---|---|---|
| 6.737 | 0.25 | 0.8 | 0.2 | **0.699** |

To estimate emission from part of national population, not connected to waste water treatment plants, recommendations from Technical Expert Review Team (TERT) during EU Effort Sharing Decision (EU ESD) voluntary review in 2015 was followed and estimation of use of septic tanks and latrines among national population was performed.

Proportion of urban and rural population was taken from The World Bank data[249], default "suggested values for urbanisation and degree of utilization of treatment, pathway or method" from 2006 IPCC Guidelines were used (since there wasn't Latvia in the list, values for neighbour country Russia were used).

It was estimated, that 83.4% from national population, not connected to waste water treatment, are served by septic tanks, while 16.6% - with latrines (2014). Corresponding default, MCF values from 2006 IPCC Guidelines were chosen to estimate emissions of $CH_4$ from this source (Table 7.20).

**Table 7.20 Estimation of $CH_4$ emissions from national population, not connected to waste water treatment plants (2014)**

| Type of treatment or discharge pathway | Part of not connected national population, using treatment or discharge pathway | MCF | Emission factor, kg $CH_4$/kg BOD | Emissions of $CH_4$, kt/y |
|---|---|---|---|---|
| Septic tanks | 83.4% | 0.5 | 0.3 | 2.557 |
| Latrines | 16.6% | 0.7 | 0.42 | 0.712 |
| | | | Total: | **3.269** |

Thus, total $CH_4$ emission from domestic waste water handling and sewage sludge in 2014 is 4.380 kt of $CH_4$ (Table 7.21).

**Table 7.21 Total $CH_4$ emissions from domestic waste water handling sector (2014)**

| **Source of $CH_4$ emissions** | **Emissions of $CH_4$, kt/y** |
|---|---|
| Emissions from waste water, treated in waste water treatment plants | 0.327 |
| Emissions from leakage from recovered $CH_4$ | 0.085 |
| Emissions from anaerobic sewage sludge | 0.699 |
| Emissions from national population, not connected to treatment plant | 3.269 |
| **Total:** | 4.380 |

[249] http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS

Calculation of emissions of $N_2O$ from Domestic Waste Water handling is based on amount of nitrogen, generated from the protein consumption by national population. Number of national population is taken from national statistics (CSB) while country specific values of protein consumption are obtained from web site http://chartsbin.com/view/1155 (Table 7.22).

**Table 7.22 Consumption of protein in Latvia per capita (1990 - 2014)**

| Time period | g/person/day | kg/person/yr |
|---|---|---|
| 1990 - 1994 | 102 | 37.23 |
| 1995 - 1999 | 89 | 32.485 |
| 2000 - 2004 | 81 | 29.565 |
| 2005 - 2014 | 88 | 32.12 |

When compared with similar data from Latvian neighbour countries (Lithuania and Estonia), Latvian data shows consistent value (Table 7.23).

**Table 7.23 Comparison of Latvian protein consumption data with data from neighbour countries (Lithuania and Estonia)**

| Country | g/person/day | kg/person/yr |
|---|---|---|
| Latvia | 81…102 | 29.565…37.23 |
| Lithuania | 77.4…78.1* | 28.251…28.507** |
| Estonia | 101* | 36.865** |

**Data taken from Lithuanian and Estonian NIRs (2010)*
***Recalculated for comparison*

Amount of $N_2O$ emission from Domestic Waste Water Handling is calculated according to 2006 IPCC Guidelines; Chapter 6.3.1 „Methodological issues".

$$N_2O_{Emissions} = N_{Effluent} \bullet EF_{Effluent} \bullet \frac{44}{28}$$

*where:*
*$N_2O_{Emissions}$ – $N_2O$ emission in inventory year, kg $N_2O$/yr*
*$N_{Effluent}$ – Nitrogen in the effluent discharged to aquatic environment*
*$EF_{Effluent}$ – Emission factor for $N_2O$ emissions from discharged waste water, kg $N_2O$-N/kg N*

$$N_{Effluent} = (P \bullet \mathrm{Pr}\,otein \bullet F_{NPR} \bullet F_{NON-CON} \bullet F_{IND-COM}) - N_{Sludge}$$

*where:*
*$N_{Effluent}$ – Total annual amount of nitrogen in waste water effluent, kg N/yr*
*P – National population*
*Protein – Annual per capita protein consumption, kg/pers/y*
*$F_{NPR}$ – Fraction of nitrogen in protein, kg N/kg protein*
*$F_{NON-COM}$ – Factor for non-consumed protein added to waste water*
*$F_{IND-COM}$ – Factor for industrial and commercial co-discharged protein into a sewer system*
*$N_{Sludge}$ – Nitrogen removed with sludge, kg N/y*

Default value for nitrogen fraction in protein – 0.16 kg N/kg protein – is used in calculation. Default emission factor – 0.005 kg $N_2O$-N/kg N – was used as well. Both values were taken from 2006 IPCC Guidelines, as well as factors for non-consumed (for countries with garbage disposals) and industrial and commercial protein co-discharged in the sewer system.

Content of Nitrogen in the dry solids of sewage sludge was already shown in the table with characteristics of sewage sludge in Latvia (Table 7.18).

A small amount of $N_2O$ is emitted during the release from the sewage system. The calculations give emission 0.054 kt $N_2O$ (2014).

$N_2O$ emissions from centralized waste water treatment processes are estimated as well.

$$N_2O_{Plants} = P \bullet T_{Plant} \bullet F_{IND-COM} \bullet EF_{Plant}$$

*where:*
$N_2O_{Plants}$ *– Total $N_2O$ emissions from plants in the inventory year, kg $N_2O$/y*
*P – Human population*
$T_{Plant}$ *– Degree of utilization of modern, centralized treatment plants, %*
$F_{IND-COM}$ *– Fraction of industrial and commercial co-discharged protein*
$EF_{Plant}$ *– Emission factor, g $N_2O$/pers/y*

Waste water treatment plants, providing tertiary treatment (i.e. removal of nitrogen of phosphorus), are considered to be in compliance with requirements for "modern, centralized treatment plants". Degree of their utilization is estimated based on number of national population, provided with such treatment. National waste water database "2-Water" provides according statistical data (starting from 2000). Constant value of 3% was used for years, previous to 2000.

Activity data for estimation emissions of $N_2O$ from Domestic Waste Water Handling sector are shown in the following Table 7.24.

**Table 7.24 Activity data for estimation emissions of $N_2O$ from Domestic Waste Water Handling sector**

| Year | Population | Amount of sludge produced, t/y | Degree of utilization of modern, centralized treatment plants, % |
|---|---|---|---|
| 1990 | 2 668 140 | 36 115 | 3.0 |
| 1995 | 2 500 580 | 25 695 | 3.0 |
| 2000 | 2 377 383 | 18 234 | 1.0 |
| 2001 | 2 353 384 | 23 153 | 4.9 |
| 2002 | 2 320 956 | 21 467 | 7.6 |
| 2003 | 2 299 390 | 29 278 | 4.3 |
| 2004 | 2 276 520 | 36 164 | 8.9 |
| 2005 | 2 249 724 | 28 877 | 8.4 |
| 2006 | 2 227 874 | 23 942 | 9.2 |
| 2007 | 2 208 840 | 23 259 | 9.3 |
| 2008 | 2 191 810 | 19 263 | 12.0 |
| 2009 | 2 162 834 | 22 346 | 14.5 |
| 2010 | 2 120 504 | 21 395 | 16.4 |
| 2011 | 2 070 371 | 19 728 | 18.2 |
| 2012 | 2 044 813 | 18 064 | 17.8 |
| 2013 | 2 023 825 | 20 733 | 17.4 |
| 2014 | 2 001 468 | 22 078 | 23.4 |

Default values from 2006 IPCC Guidelines are used for fraction of industrial and commercial co-discharged protein and emission factor (correspondingly, 1.25 and 3.2 g $N_2O$/pers/y). Estimation gives emission of 0.001871 kt of $N_2O$ from this subsector in 2014. Thus, total emission of $N_2O$ from Domestic Waste Water Handling was 0.054 + 0.002 = 0.056 kt $N_2O$, what makes decrease of 38.4% in comparison with emissions of 1990 and decrease of 0.9% in comparison with emissions of 2013.

#### 7.5.1.3 Uncertainties and times-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The following uncertainties were used for Domestic Waste Water Handling sector for activity data and emission factors (Table 7.25).

**Table 7.25 Uncertainties for Domestic Waste Water Handling sector**

| Emission | Activity data | Emission factor |
|---|---|---|
| $CH_4$ | 45% | 30%* |
| $N_2O$ | 140% | 30%* |

**30% - default uncertainty from 2006 IPCC Guidelines*

Uncertainties for activity data of each subsector are estimated using similar methodology. To estimate an uncertainty for certain subsector, its activity data are drawn on chart for each year, then the mathematical relationship of activity data timeline is found as equation of the trend line. Then "theoretical values" of activity data is calculated for each year, using the equation of the trend line, and uncertainty being calculated as deviation (in %) of "actual" value from the "theoretical" one (Figure 7.15).

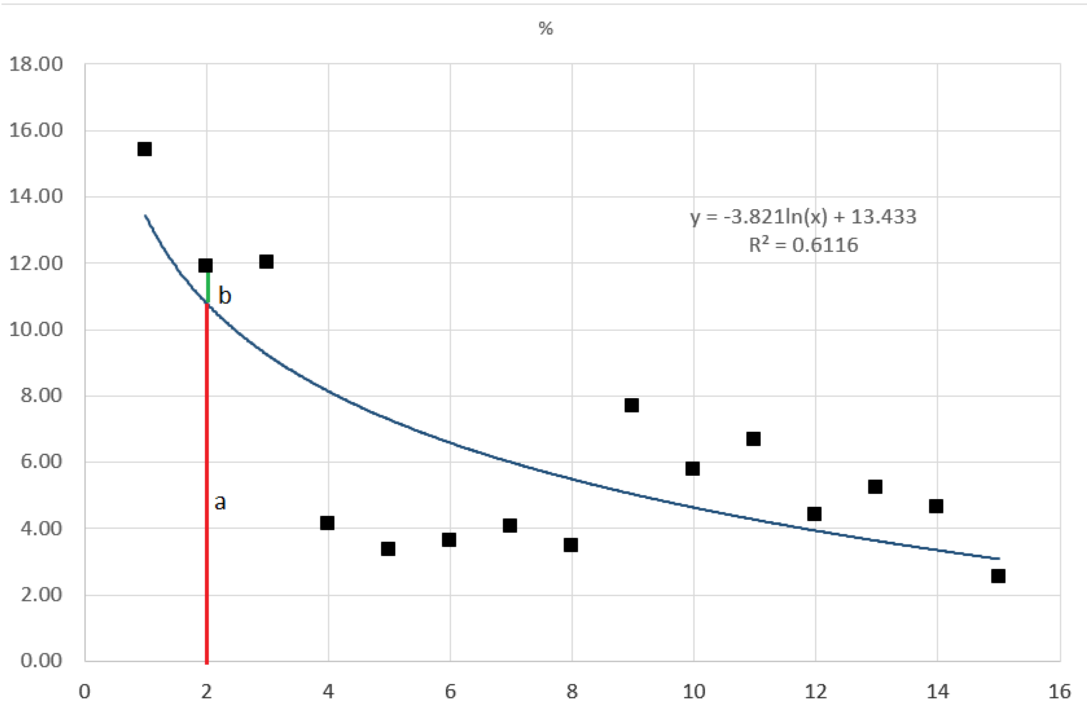


**Figure 7.15 Example of estimation of uncertainties in Waste Water Handling sector**

Each deviance is calculated as:

$$Uncertaint\,y,\% = \frac{100 \bullet |b|}{a}$$

*where:*
*a – "theoretical" value of activity data, calculated through equation of the trend line*
*b – difference between "theoretical" and "actual" value of activity data for certain year*

Total uncertainty for certain type of activity data is calculated as average for entire timeline. Then total uncertainty for subsector is being calculated, using following formula:

$$X = \sqrt{x_1^2 + x_2^2 + \ldots + x_i^2}$$

*where:*
*X – total uncertainty for subsector*
*$x_1$, $x_2$, $x_i$ – uncertainties for each type of activity data for certain subsector*

Time series show continuous decrease of emissions in the entire timeline. Main reason of this decrease is recovery of $CH_4$ and implementation of more and better treatment plants also can be observed.

Inconsistencies in data (for example, potential outlier in 2003) can be explained with quality of activity data. Although data collection system on population, receiving certain grade of waste water treatment is generally well-designed and allows to collect data on plant level, the actual data quality still largely depends on competence of person in enterprise, responsible for reporting these data, as well as inspector of regional environmental board, who assesses and accepts the survey with plant level data.

#### 7.5.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.G. sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

Following procedures of quality assurance and quality control were carried out:

- Statistic data of national population, served by certain treatment type and level, as well as amount of sludge produced and disposed are collected through annual state statistical survey "2-Water". In frames of this survey, enterprises, performing collection and treatment of waste water, submit their data using online database. Reported data are checked by Latvian State Environment Service, whose environment inspectors approve reports or return them to submitters for correcting of data;
- Units of measurement were checked during comparison with results of previous reports;
- Number of national population was cross-checked with activity data, used in others sectors (solvents and waste disposal);

- Amount of $CH_4$ recovery from sewage sludge was checked by comparing data from Energetic sector on amount of sludge gas burned in waste water treatment facility;
- Protein consumption data were compared with values from neighbour countries of Latvia – Lithuania and Estonia (see Table 7.23);
- Comments in CRF tables were checked in process of entering data of calculation and recalculation results in CRF tables.

#### 7.5.1.5 Category-specific recalculations

$CH_4$ emission data were recalculated in Domestic Waste Water Handling sector due to adjustment of methodology and activity data for period 1993 – 2013.

$N_2O$ emission data were recalculated for entire timeline due to correction of mistake in the assessment of emission factor and applying of dynamic values of protein consumption or entire reporting period.

#### 7.5.1.6 Category-specific planned improvements

It is planned to continue studies regarding sewage sludge storage conditions and characteristics in the country.

### 7.5.2 Industrial Wastewater (CRF 5.D.2)

#### 7.5.2.1 Category description

Industrial Waste Water Handling is responsible for $CH_4$ and $N_2O$ emissions. Fluctuations of methane emission from Industrial Waste Water Handling are connected with fluctuations of amount of production produced, which is activity data for this sector. Significant decrease in methane emission in period 1993 – 1999 is due to decrease of economic activity after collapse of Soviet Union. Emission of $N_2O$, produced by Industrial Waste Water Handling, is negligible, giving approximately 0.1% of emission in this sector in 2014.

Totally, emissions from Industrial Waste Water Handling sector made 138.6 kt $CO_2$ eq. in 2014, what makes decrease of 0.5% in comparison to emissions of 1990 and increase of 1.6% in comparison to emissions of 2013 (Figure 7.16).

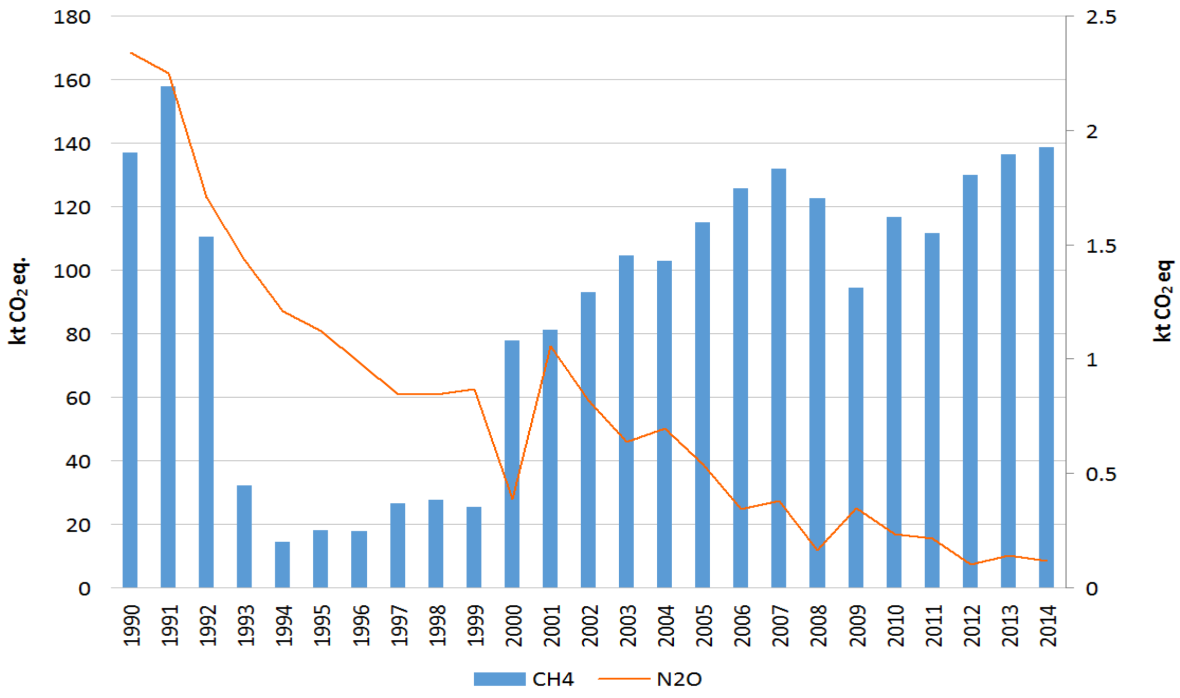


**Figure 7.16 Emissions from Industrial Waste Water Handling sector[250] (kt $CO_2$ eq.)**

### 7.5.2.2 Methodological issues

Emissions of $CH_4$ from Industrial Waste Water Handling is calculated from amount of total organic product (expressed as COD – chemical oxygen demand) and total nitrogen in waste water, generated in certain branches of industry (mostly food-processing industry).

2006 IPCC Guidelines default formula from chapter 6.2.3 „Industrial Wastewater" was used for calculation of $CH_4$ emission from Industrial Waste Water Handling sector.

$$CH_4 = \sum_i \left[ (TOW_i - S_i) \bullet EF_i - R_i \right]$$

*where:*
*$CH_4$– $CH_4$ emissions in inventory year, kg $CH_4$/yr*
*$TOW_i$ – total organically degradable material in industrial waste water from industry i in inventory year, kg COD/yr*
*i – industrial sector*
*$S_i$ – organic component removed with sludge in the inventory year, kg COD/yr*
*$EF_i$ – emission factor for industry i, kg $CH_4$/kg COD*
*$R_i$ – amount of $CH_4$ recovered in inventory year, kg $CH_4$*

$$EF_i = B_o \bullet MCF_i$$

*where:*
*EFi – emission factor for each industry i, kg $CH_4$/kg COD*

[250] *$N_2O$ on secundary axis*

*i – each type of industry*
*$B_o$ – maximum $CH_4$ producing capacity, kg $CH_4$/kg COD*
*MCFi – methane correction factor for each type of industry*

$$TOW_i = P_i \bullet W_i \bullet COD_i$$

*where:*
*$TOW_i$ – total organically degradable material for industry i, kg COD/yr*
*i – industrial sector*
*$P_i$ – total industrial product for industry i, t/yr*
*$W_i$ – waste water generated for each type of industry, $m^3$/t product*
*$COD_i$ – industrial degradable organic component in waste water, kg COD/$m^3$*

Activity data (amount of certain industrial products) was taken from national statistics – CSB data base. Default IPCC value 0.25 kg $CH_4$/kg COD was used for maximum methane producing capacity, as it is recommended in 2006 IPCC Guidelines. Amount on generation of waste water per certain type of product and organic component in that waste water were taken as default values from 2006 IPCC Guidelines.

Plant specific survey was performed during 2012, to obtain MCF values for certain industries. The average weighted MCF for each industry were estimated depending of level of contribution of said industry in terms of amount of waste water generated and its fate (level of treatment or transfer to certain urban waste water treatment plant).

Assumptions for all relevant industries are summarized in Table 7.26.

**Table 7.26 Assumptions used for calculation of $CH_4$ emissions from Industrial Waste Water Handling**

| Industry type | Generation of waste water, $m^3$/t of product* | Organic component in waste water, kg COD/$m^3$* | Weighted MCF value** |
|---|---|---|---|
| Milk | 7 | 2.7 | 0.10 |
| Meat | 13 | 4.1 | 0.15 |
| Fish | 13 | 2.5 | 0.05 |
| Beer | 6.3 | 2.9 | 0.04 |
| Fruits and vegetables | 20 | 5 | 0.13 |
| Sugar | 11 | 3.2 | 0.50 |
| Paper and pulp | 162 | 9 | 0.30 |
| Plastics | 0.6 | 3.7 | 0.14 |
| Organic chemicals | 67 | 3 | 0.03 |

**Assumptions used from 2006 IPCC Guidelines*
***rounded to 2 decimal positions*

Organic component removed with sludge and amount of recovered $CH_4$ under this sector is assumed to be 0 – both values are estimated and taken into account under the Domestic Waste Water Handling sector.

Activity data, used for calculation of $CH_4$ emissions from domestic waste water are summarized in the following Table 7.27.

**Table 7.27 Activity data for calculation $CH_4$ emissions from Industrial Waste Water Handling sector (amount of products, th. t/yr)**

| Year | Milk | Meat | Fish | Beer | Fruits and vegetables | Sugar | Paper and pulp | Plastics | Organic chemicals |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 1 188 | 324 | 335 | 9 | 0 | 31 | 37 | 0 | 0 |
| 1995 | 353 | 99 | 114 | 66 | 0 | 29 | 1.5 | 0 | 0 |
| 2000 | 175 | 65 | 82 | 95 | 35 | 63 | 22 | 19 | 12 |
| 2001 | 184 | 70 | 107 | 101 | 41 | 56 | 23 | 24 | 14 |
| 2002 | 171 | 87 | 102 | 122 | 46 | 77 | 27 | 30 | 15 |
| 2003 | 177 | 103 | 83 | 139 | 43 | 75 | 31 | 38 | 16 |
| 2004 | 192 | 116 | 76 | 134 | 42 | 67 | 30 | 27 | 16 |
| 2005 | 207 | 123 | 88 | 131 | 42 | 71 | 34 | 29 | 4 |
| 2006 | 230 | 143 | 86 | 143 | 38 | 60 | 38 | 30 | 5 |
| 2007 | 240 | 148 | 76 | 143 | 32 | 0 | 43 | 33 | 25 |
| 2008 | 224 | 145 | 85 | 136 | 37 | 0 | 39 | 25 | 25 |
| 2009 | 195 | 121 | 55 | 130 | 27 | 0 | 30 | 16 | 51 |
| 2010 | 197 | 120 | 56 | 150 | 27 | 0 | 38 | 19 | 51 |
| 2011 | 183 | 121 | 60 | 150 | 18 | 0 | 37 | 20 | 4 |
| 2012 | 192 | 126 | 73 | 140 | 18 | 0 | 43 | 23 | 5 |
| 2013 | 211 | 122 | 73 | 134 | 19 | 0 | 46 | 26 | 5 |
| 2014 | 206 | 116 | 64 | 83 | 19 | 0 | 47 | 24 | 9 |

Example of $CH_4$ emission calculation from Industrial Waste Water Handling is provided in a Table 7.28.

**Table 7.28 Calculation example of emission of $CH_4$ from Industrial Waste Water Handling (2014)**

| Product name | Amount of production,1000 t/yr | Amount of waste water per production unit, m³/t | Amount of waste water, 1000 m³/yr | Conc.of COD in waste water, kg/m³ | Load of COD, t/yr | Max.$CH_4$ prod. capacity, kg $CH_4$/ kg COD | MCF | Emission of $CH_4$, t/yr or Mg/yr |
|---|---|---|---|---|---|---|---|---|
| | a | b | c = a*b | d | e = c*d | f | g | h = e*f*g |
| **Milk** | 206 | 7 | 1 443 | 2.7 | 3 897 | 0.25 | 0.10 | 98 |
| **Meat** | 116 | 13 | 1 507 | 4.1 | 6 177 | 0.25 | 0.15 | 230 |
| **Fish** | 64 | 13 | 833 | 2.5 | 2 083 | 0.25 | 0.05 | 26 |
| **Sugar** | 0 | 11 | 0 | 3.2 | 0 | 0.25 | 0.5 | 0 |
| **Beer** | 83 | 6.3 | 525 | 2.9 | 1 522 | 0.25 | 0.04 | 15 |
| **Fruits and vegetables** | 19 | 20 | 389 | 5 | 1 945 | 0.25 | 0.13 | 61 |
| **Paper and pulp** | 47 | 162 | 7 549 | 9 | 67 943 | 0.25 | 0.30 | 5 096 |
| **Plastics** | 24 | 0.6 | 14 | 3.7 | 53 | 0.25 | 0.14 | 2 |
| **Organic chemicals** | 9 | 67 | 612 | 3 | 1 837 | 0.25 | 0.03 | 13 |

Thus, total emission of $CH_4$ from Industrial Waste Water treatment in 2014 was 5.541 kt of $CH_4$, what makes 1.1% increase if compared to emission of 1990 and 1.6% increase if compared with emission of 2013.

$N_2O$ emission from Industrial Waste Water Handling was calculated, using Tier 1 method from 2006 IPCC Guidelines, chapter 6.3.1 "Nitrous Oxide Emissions from Wastewater". Calculation is based on load of nitrogen in the industrial waste water:

$$WM = N_{ef} \bullet EF \bullet \frac{44}{28} \bullet 10^{-6}$$

*where:*
*WM – total emission of $N_2O$ from industrial waste water handling in kt $N_2O$*
*$N_{ef}$ – load of nitrogen, kg/yr*
*EF – emission factor, kg $N_2O$-N/kg N*

Default value (0.005 kg $N_2O$-N/kg N) from 2006 IPCC Guidelines was used for calculation.

Activity data, used for calculation of $N_2O$ emissions from Industrial Waste Water Handling, are summarized in Table 7.29:

**Table 7.29 Activity data for calculation $N_2O$ emissions from Industrial Waste Water Handling sector**

| Year | Load of N in industrial waste water, t/yr |
|---|---|
| 1990 | 1 000 |
| 1995 | 480 |
| 2000 | 165 |
| 2001 | 452 |
| 2002 | 350 |
| 2003 | 272 |
| 2004 | 297 |
| 2005 | 230 |
| 2006 | 147 |
| 2007 | 162 |
| 2008 | 70 |
| 2009 | 149 |
| 2010 | 101 |
| 2011 | 92 |
| 2012 | 43 |
| 2013 | 60 |
| 2014 | 49 |

$N_2O$ emission from Industrial Waste Water Handling is negligible – 0.0004 kt/yr (2014), what makes decrease of 95.1% if compared to emissions of 1990 and decrease of 18.2% if compared to emission of 2013.

#### 7.5.2.3 Uncertainties and times-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The following uncertainties were used for Industrial Wastewater Handling sector for activity data and emission factors (Table 7.30).

**Table 7.30 Uncertainties for Industrial Waste Water Handling sector**

| Emission | Activity data | Emission factor |
|---|---|---|
| $CH_4$ | 64%* | 30%** |
| $N_2O$ | 23% | 30%** |

**frame uncertainty of CSB*
***default uncertainty from 2006 IPCC Guidelines*

Uncertainties for activity data in Industrial Waste Water Handling) are estimated similarly as uncertainties for activity data for Domestic Waste Water subsector (see Chapter 7.5.1.3).

Time series of emissions are fluctuating since Industrial Waste Water Handling is significant source of $CH_4$ emissions and amount of production, which is activity data for it, varies a lot from year to year. Decrease of emissions from Industrial Waste Water Handling in period 1992 – 2001 can also be explained by decrease of national economic activity after collapse of Soviet Union in 1991.

$N_2O$ emission activity data and emissions from Industrial Waste Water are also fluctuating , however its effect on total emissions from this sector is not significant, because of small amount of $N_2O$ emitted.

#### 7.5.2.4 Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.G. sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

Following procedures of quality assurance and quality control were carried out:

- Statistic data of nitrogen load in waste water (including industrial waste water) are collected through annual state statistical survey "2-Water". In frames of this survey, enterprises, performing collection and treatment of waste water, submit their data using online database. Reported data are checked by Latvian State Environment Service, whose environment inspectors approve reports or return them to submitters for correcting of data;
- Units of measurement were checked during comparison with results of previous reports;
- Comments in CRF tables were checked in process of entering data of calculation and recalculation results in CRF tables.

#### 7.5.2.5 Source-specific recalculations

Emissions of $CH_4$ were recalculated for period 2000 – 2013 due to adjustment of activity data.

#### 7.5.2.6 Source-specific planned improvements

No improvements are planned.

### 7.5.3 Other (CRF 5.D.3)

#### 7.5.3.1 Category description

Data of LEGMC shows there were 182 mio $m^3$ of waste water discharged in Latvia (2014). Most of national population (76.7%, 2014) is served by urban waste water collecting and treatment. Certain amount of NMVOC is produced from Waste Water Handling sector.

### 7.5.3.2 Methodological issues

Emissions of NMVOC was calculated and using default EMEP emission factor from EMEP/EEA 2013 was used for this calculation – 15 mg of NMVOC per $m^3$ of waste water produced, what gives 0.00273 kt/yr of NMVOC (2014). It makes decrease of 69.7% if compared to emission of 1990 and decrease of 23.5% if compared to emission of 2013.

Activity data, used for this calculation, are summarized in the following Table 7.31.

**Table 7.31 Activity data for calculation NMVOC emissions from Waste Water Handling sector**

| Year | Amount of waste water produced, mio $m^3$ |
|---|---|
| 1990 | 600 |
| 1995 | 357 |
| 2000 | 257 |
| 2001 | 244 |
| 2002 | 243 |
| 2003 | 229 |
| 2004 | 211 |
| 2005 | 226 |
| 2006 | 196 |
| 2007 | 210 |
| 2008 | 191 |
| 2009 | 226 |
| 2010 | 222 |
| 2011 | 241 |
| 2012 | 234 |
| 2013 | 238 |
| 2014 | 182 |

### 7.5.3.3 Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.G. sector in order to achieve these quality objectives. Quality meetings are held annually between experts.

- Statistic data of amount of waste water produced and discharged are collected through annual state statistical survey "2-Water". In frames of this survey, enterprises, performing collection and treatment of waste water, submit their data using online database. Reported data are checked by Latvian State Environment Service, whose environment inspectors approve reports or return them to submitters for correcting of data;
- Units of measurement were checked during comparison with results of previous reports.

#### 7.5.3.4 Uncertainties and time-series consistency

Uncertainty for activity data regarding NMVOC emissions is 10%. It is calculated the same way as uncertainties for Domestic and Industrial Waste Water Handling (See Chapter 7.5.1.3 for description). EMEP/EEA 2013 does not provide uncertainty for emission factors or methodology to estimate it.

#### 7.5.3.5 Source-specific recalculations

No recalculations were performed.

#### 7.5.3.6 Source-specific planned improvements

No planned improvements.

# 8 OTHER (CRF 6)

Latvia does not report emissions under CRF 6 Other.

# 9 INDIRECT $CO_2$ AND NITROUS OXIDE EMISSIONS

### 9.1.1 Category description

In accordance with UNFCCC Annex I GHG inventory reporting guidelines Annex I Parties may report indirect $CO_2$ from the atmospheric oxidation of $CH_4$, CO and NMVOCs.

Sources of indirect $CO_2$ emissions in Latvian inventory are indirect $CO_2$ from the atmospheric oxidation of $CH_4$ and NMVOCs under Energy and IPPU sectors.

The estimation of indirect $CO_2$ emissions is based on the official Latvian inventories reported under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP).

### 9.1.2 Methodological issues

Indirect $CO_2$ emissions are generally calculated using the methodology described in the 2006 IPCC Guidelines.

In order for consistency with the reporting done by Latvia under the first commitment period of the Kyoto Protocol, the indirect $CO_2$ emissions from NMVOCs in solvent use, road paving with asphalt, asphalt roofing and glass fibre production are reported under CRF 2.D.3 Other in accordance with UNFCCC Annex I GHG inventory reporting guidelines. For submission 2016, first time other sources of indirect $CO_2$ emissions occurring in Energy and Transport sectors are calculated and reported in CRF Table 6.

According to the 2006 IPCC Guidelines, there are sources in Energy that produce indirect $CO_2$ emissions from $CH_4$ and NMVOCs. Those sources in case of Latvia are NMVOC emissions from road traffic evaporation from cars, $CH_4$ and NMVOC emissions from natural gas leakages, as well as NMVOC emissions from gasoline distribution. The general formulas to calculate indirect $CO_2$ emissions are provided below:

$$from\ CH_4: \quad inputs_{CO_2} = emissions_{CH_4} \times \frac{44}{16}$$

$$from\ NMVOC: \quad inputs_{CO_2} = emissions_{NMVOC} \times C \times \frac{44}{12}$$

*where:*
*c – fraction of carbon*

2006 IPCC Guidelines provide a default factor – 0.6 – for the fraction of carbon in NMVOC, and Latvia uses this particular value in 2016 Submission.

Separate sources and emissions are presented in Table 9.1.

**Table 9.1 Indirect $CO_2$ emissions from Energy (kt)**

| | Indirect $CO_2$ from gas leakage (NMVOC) | Indirect $CO_2$ from gas leakage ($CH_4$) | Indirect $CO_2$ from gasoline distribution (NMVOC) | Indirect $CO_2$ from gasoline evaporation (NMVOC) |
|---|---|---|---|---|
| **1990** | 6.52 | 27.23 | 2.68 | 6.99 |
| **1991** | 6.28 | 26.23 | 2.26 | 6.27 |
| **1992** | 5.73 | 23.92 | 2.17 | 6.44 |

| | Indirect $CO_2$ from gas leakage (NMVOC) | Indirect $CO_2$ from gas leakage ($CH_4$) | Indirect $CO_2$ from gasoline distribution (NMVOC) | Indirect $CO_2$ from gasoline evaporation (NMVOC) |
|---|---|---|---|---|
| **1993** | 5.48 | 22.87 | 2.10 | 5.73 |
| **1994** | 5.35 | 22.35 | 2.01 | 5.75 |
| **1995** | 5.21 | 21.77 | 1.81 | 5.38 |
| **1996** | 5.02 | 20.97 | 1.79 | 4.66 |
| **1997** | 4.69 | 19.58 | 1.65 | 4.57 |
| **1998** | 4.50 | 18.78 | 1.54 | 4.10 |
| **1999** | 4.29 | 17.91 | 1.49 | 4.30 |
| **2000** | 3.97 | 16.57 | 1.48 | 4.37 |
| **2001** | 3.87 | 16.07 | 1.55 | 4.44 |
| **2002** | 4.02 | 16.78 | 1.52 | 4.02 |
| **2003** | 3.14 | 13.10 | 1.52 | 3.30 |
| **2004** | 3.11 | 12.97 | 1.54 | 2.71 |
| **2005** | 3.51 | 14.65 | 1.51 | 1.96 |
| **2006** | 2.52 | 10.51 | 1.68 | 1.75 |
| **2007** | 4.16 | 10.79 | 1.83 | 1.17 |
| **2008** | 3.82 | 11.08 | 1.67 | 0.65 |
| **2009** | 3.98 | 10.46 | 1.40 | 0.50 |
| **2010** | 3.90 | 10.08 | 1.27 | 0.41 |
| **2011** | 1.89 | 6.93 | 1.19 | 0.40 |
| **2012** | 2.16 | 8.76 | 1.02 | 0.38 |
| **2013** | 2.83 | 11.11 | 0.93 | 0.29 |
| **2014** | 4.24 | 14.88 | 0.90 | 0.17 |

As it can be seen in the Table 9.1, the largest part of indirect $CO_2$ emissions contributes to natural gas leakage (94.7%).

### 9.1.3 Uncertainties and times-series consistency

Uncertainty analysis for 2016 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6

Information regarding uncertainties for 2.D.3 sector can be found under chapter 4.5.3.3.

### 9.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in order to achieve these quality objectives. Quality meetings are held annually between experts.

### 9.1.5 Category-specific recalculations

In 2015 submission indirect $CO_2$ emissions occuring in CRF 2.D.3 were reported outside of IPPU sector and reflected in Table 6. But in order to ensure compliance with the reporting done by Latvia under the first commitment period of the Kyoto Protocol, it was decided the indirect $CO_2$ emissions from NMVOCs in solvent use, road paving with asphalt, asphalt roofing and glass fibre production to report under CRF 2.D.3.

### 9.1.6 Category-specific improvements

No improvements are planned for this sector.

# 10 RECALCULATIONS AND IMPROVEMENTS

## *10.1 Explanations and justifications for recalculations, including KP-LULUCF inventory*

### 10.1.1 GHG inventory

The changes in inventory since the previous submission to the UNFCCC were done according to:

- Recommendations by Technical expert review team (TERT) during European Union Effort sharing decision (EU ESD)[251] voluntary review in 2015[252] and EU ESD review in 2016;
- Recommendations by Expert review team (ERT) according to Report on the individual review of the annual submission of Latvia submitted in 2014[253];
- Suggestions from the third part experts not directly involved in the preparation of national inventory (LULUCF, KP-LULUCF sector);
- Corrections of activity data by CSB and corrections of input mistakes.

Overall impacts of recalculations since 1990 are summarized in Table 10.1.

**Table 10.1 Impacts of recalculations on national emissions**

| | | Previous submission | Latest submission | Difference | Difference |
|---|---|---|---|---|---|
| | | $CO_2$ equivalent (kt) | | | (%) |
| **1990** | Total $CO_2$ Eq Emissions with LULUCF | 17284.87 | 17834.80 | 549.93 | 3.18 |
| | Total $CO_2$ Eq Emissions without LULUCF | 26184.37 | 26256.43 | 72.06 | 0.28 |
| **1991** | Total $CO_2$ Eq Emissions with LULUCF | 15063.89 | 15587.93 | 524.04 | 3.48 |
| | Total $CO_2$ Eq Emissions without LULUCF | 24214.61 | 24269.68 | 55.07 | 0.23 |
| **1992** | Total $CO_2$ Eq Emissions with LULUCF | 8975.77 | 9508.84 | 533.07 | 5.94 |
| | Total $CO_2$ Eq Emissions without LULUCF | 19460.45 | 19524.00 | 63.55 | 0.33 |
| **1993** | Total $CO_2$ Eq Emissions with LULUCF | 6171.63 | 6865.72 | 694.09 | 11.25 |
| | Total $CO_2$ Eq Emissions without LULUCF | 15873.39 | 16108.10 | 234.70 | 1.48 |
| **1994** | Total $CO_2$ Eq Emissions with LULUCF | 3479.14 | 4148.37 | 669.22 | 19.24 |
| | Total $CO_2$ Eq Emissions without LULUCF | 14020.70 | 14209.92 | 189.22 | 1.35 |
| **1995** | Total $CO_2$ Eq Emissions with LULUCF | 3111.38 | 3761.25 | 649.87 | 20.89 |
| | Total $CO_2$ Eq Emissions without LULUCF | 12617.28 | 12799.16 | 181.88 | 1.44 |

[251] *http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009D0406&from=EN*
[252] *https://emrt.eea.europa.eu/*
[253] *http://unfccc.int/resource/docs/2015/arr/lva.pdf*

| | | Previous submission | Latest submission | Difference | Difference |
|---|---|---|---|---|---|
| | | $CO_2$ equivalent (kt) | | | (%) |
| **1996** | Total $CO_2$ Eq Emissions with LULUCF | 2479.16 | 3125.77 | 646.61 | 26.08 |
| | Total $CO_2$ Eq Emissions without LULUCF | 12632.97 | 12849.42 | 216.45 | 1.71 |
| **1997** | Total $CO_2$ Eq Emissions with LULUCF | 3576.33 | 4242.03 | 665.69 | 18.61 |
| | Total $CO_2$ Eq Emissions without LULUCF | 12064.06 | 12296.11 | 232.05 | 1.92 |
| **1998** | Total $CO_2$ Eq Emissions with LULUCF | 3940.57 | 4608.63 | 668.05 | 16.95 |
| | Total $CO_2$ Eq Emissions without LULUCF | 11549.00 | 11788.17 | 239.17 | 2.07 |
| **1999** | Total $CO_2$ Eq Emissions with LULUCF | 6461.99 | 7149.43 | 687.45 | 10.64 |
| | Total $CO_2$ Eq Emissions without LULUCF | 10750.18 | 11003.11 | 252.93 | 2.35 |
| **2000** | Total $CO_2$ Eq Emissions with LULUCF | 3016.55 | 3738.30 | 721.75 | 23.93 |
| | Total $CO_2$ Eq Emissions without LULUCF | 10147.24 | 10434.07 | 286.83 | 2.83 |
| **2001** | Total $CO_2$ Eq Emissions with LULUCF | 2826.03 | 3528.68 | 702.65 | 24.86 |
| | Total $CO_2$ Eq Emissions without LULUCF | 10754.33 | 11038.46 | 284.13 | 2.64 |
| **2002** | Total $CO_2$ Eq Emissions with LULUCF | 4286.98 | 4973.87 | 686.89 | 16.02 |
| | Total $CO_2$ Eq Emissions without LULUCF | 10729.39 | 11010.57 | 281.18 | 2.62 |
| **2003** | Total $CO_2$ Eq Emissions with LULUCF | 4933.33 | 5609.57 | 676.24 | 13.71 |
| | Total $CO_2$ Eq Emissions without LULUCF | 10890.64 | 11171.32 | 280.68 | 2.58 |
| **2004** | Total $CO_2$ Eq Emissions with LULUCF | 6399.79 | 7089.66 | 689.87 | 10.78 |
| | Total $CO_2$ Eq Emissions without LULUCF | 10850.90 | 11166.82 | 315.93 | 2.91 |
| **2005** | Total $CO_2$ Eq Emissions with LULUCF | 6941.58 | 7651.48 | 709.90 | 10.23 |
| | Total $CO_2$ Eq Emissions without LULUCF | 11039.79 | 11380.36 | 340.57 | 3.08 |
| **2006** | Total $CO_2$ Eq Emissions with LULUCF | 6453.24 | 7182.55 | 729.31 | 11.30 |
| | Total $CO_2$ Eq Emissions without LULUCF | 11543.31 | 11899.29 | 355.97 | 3.08 |
| **2007** | Total $CO_2$ Eq Emissions with LULUCF | 7567.40 | 8313.44 | 746.05 | 9.86 |
| | Total $CO_2$ Eq Emissions without LULUCF | 11991.85 | 12364.87 | 373.02 | 3.11 |
| **2008** | Total $CO_2$ Eq Emissions with LULUCF | 6759.39 | 7511.32 | 751.94 | 11.12 |
| | Total $CO_2$ Eq Emissions without LULUCF | 11562.85 | 11940.64 | 377.79 | 3.27 |

| | | Previous submission | Latest submission | Difference | Difference |
|---|---|---|---|---|---|
| | | $CO_2$ equivalent (kt) | | | (%) |
| **2009** | Total $CO_2$ Eq Emissions with LULUCF | 9625.27 | 10577.28 | 952.01 | 9.89 |
| | Total $CO_2$ Eq Emissions without LULUCF | 10803.02 | 11217.68 | 414.66 | 3.84 |
| **2010** | Total $CO_2$ Eq Emissions with LULUCF | 12778.46 | 13936.31 | 1157.85 | 9.06 |
| | Total $CO_2$ Eq Emissions without LULUCF | 11896.94 | 12361.52 | 464.58 | 3.91 |
| **2011** | Total $CO_2$ Eq Emissions with LULUCF | 11642.50 | 12967.06 | 1324.55 | 11.38 |
| | Total $CO_2$ Eq Emissions without LULUCF | 11130.56 | 11601.95 | 471.39 | 4.24 |
| **2012** | Total $CO_2$ Eq Emissions with LULUCF | 10549.81 | 12152.61 | 1602.81 | 15.19 |
| | Total $CO_2$ Eq Emissions without LULUCF | 10966.65 | 11493.46 | 526.81 | 4.80 |
| **2013** | Total $CO_2$ Eq Emissions with LULUCF | 10765.95 | 12623.30 | 1857.35 | 17.25 |
| | Total $CO_2$ Eq Emissions without LULUCF | 10913.73 | 11414.54 | 500.82 | 4.59 |

Recalculations made for the 2016 inventory submission by CRF category and gas and their implications to the emission level in 1990 and 2013 as well as explanations for recalculations are provided in following Table 10.2, Table 10.3, Table 10.4 and Table 10.5.

**Table 10.2 Recalculations made in 2016 submission (recalculated year 2013)**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| **1. Energy** | $CO_2$ | 6705.77 | 6700.17 | -5.60 | -0.08 | -0.08 | -0.07 | |
| A. Fuel combustion activities | $CO_2$ | 6705.76 | 6700.16 | -5.60 | -0.08 | -0.08 | -0.07 | |
| 2. Manufacturing industries and construction | $CO_2$ | 761.10 | 755.52 | -5.58 | -0.73 | -0.08 | -0.07 | Precised amounts of anthracite and other biogas; excluded amounts of coke in 1A2a sector (allocated to 2C1 sector) recalculated waste amounts and emissions in 2013. |
| 3. Transport | $CO_2$ | 2772.11 | 2772.10 | -0.02 | 0.00 | 0.00 | 0.00 | Recalculations have been done due to improvement of activity data and corrected gasoline consumption in road transport. |
| **2. Industrial processes and product use** | $CO_2$ | 551.98 | 613.55 | 61.57 | 11.15 | 0.84 | 0.82 | |
| A. Mineral industry | $CO_2$ | 549.95 | 550.26 | 0.32 | 0.06 | 0.00 | 0.00 | Recalculations have been done for years 2012-2014 in sector 2.A.3 due to data of soda ash used in direct glass production are available and indirect $CO_2$ emissions from glass fibre production are reported under this sector. |
| C. Metal industry | $CO_2$ | 0.96 | 13.90 | 12.94 | 1354.94 | 0.18 | 0.17 | Recalculations have been done in all time series in sector 2.C.1 due to data of used carburizators (coke, coke fine etc.) are taken into account and allocated from Energy sector to IPPU. |
| D. Non-energy products from fuels and solvent use | $CO_2$ | 1.08 | 49.39 | 48.31 | 4482.32 | 0.66 | 0.65 | In 2015 submission indirect $CO_2$ emissions occuring in CRF 2.D.3 were reported outside of IPPU sector and reflected in Table 6. But in order to ensure compliance with the reporting done by Latvia under the first commitment period of the |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Kyoto Protocol, it was decided the indirect $CO_2$ emissions from NMVOCs in solvent use, road paving with asphalt, asphalt roofing and glass fibre production to report under CRF 2.D.3. In 2015/2016 recalculations for period 1990-2014 have been carried out under Solvent Use sector due the corrected list of NMVOCs substances and change of method for all time series in accordance with EMEP/EEA 2013 for all time series (see Chapter 4.5.3.2.).<br>Also recalculations were made in 2.D.1 and 2.D.2 sectors due to correction of mistake in calculation which affects $CO_2$ emissions in all time series. |
| **4. Land use, land-use change and forestry (net)** | $CO_2$ | -1195.27 | 151.51 | 1346.79 | -112.68 | | 17.98 | |
| A. Forestland | $CO_2$ | -3952.38 | -3178.15 | 774.24 | -19.59 | | 10.34 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| B. Cropland | $CO_2$ | 2700.97 | 2901.49 | 200.52 | 7.42 | | 2.68 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| C. Grassland | $CO_2$ | 188.32 | 387.35 | 199.03 | 105.68 | | 2.66 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| D. Wetlands | $CO_2$ | 1003.23 | 1003.23 | 0.00 | 0.00 | | 0.00 | Revision of land use category due to manual check of land use categories entered in the NFI database. |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| E. Settlements | $CO_2$ | 1006.11 | 901.75 | -104.36 | -10.37 | | -1.39 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| G. Harvested wood products | $CO_2$ | -2141.52 | -1864.16 | 277.36 | -12.95 | | 3.70 | More accurate activity data. |
| **International bunkers** | $CO_2$ | 1118.11 | 1116.53 | -1.57 | -0.14 | -0.02 | -0.02 | |
| Aviation | $CO_2$ | 375.15 | 373.58 | -1.57 | -0.42 | -0.02 | -0.02 | Recalculations have been done due to corrected number of LTO and fuel consumption for representative aircraft type in LTO cycle. |
| **$CO_2$ emissions from biomass** | $CO_2$ | 5992.02 | 5978.02 | -14.00 | -0.23 | -0.19 | -0.19 | Precised activity data by CSB. |
| **Indirect $CO_2$** | $CO_2$ | 111.70 | 15.16 | -96.55 | -86.43 | -1.32 | -1.29 | In 2015 submission indirect $CO_2$ emissions occuring in CRF 2.D.3 were reported outside of IPPU sector (under Indirect $CO_2$) and reflected in Table 6. But in order to ensure compliance with the reporting done by Latvia under the first commitment period of the Kyoto Protocol, it was decided the indirect $CO_2$ emissions from NMVOCs in solvent use, road paving with asphalt, asphalt roofing and glass fibre production to report under CRF 2.D.3. |
| | | | | | | | | |
| **1. Energy** | $CH_4$ | 359.11 | 279.55 | -79.56 | -22.16 | -3.96 | -3.35 | |
| A. Fuel combustion activities | $CH_4$ | 258.11 | 178.55 | -79.56 | -30.83 | -3.96 | -3.35 | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| 2. Manufacturing industries and construction | $CH_4$ | 12.09 | 12.20 | 0.11 | 0.92 | 0.01 | 0.00 | Precised amounts of anthracite and other biogas; excluded amounts of coke in 1A2a sector (allocated to 2C1 sector) recalculated waste amounts and emissions in 2013. |
| 3. Transport | $CH_4$ | 4.77 | 5.04 | 0.27 | 5.69 | 0.01 | 0.01 | Recalculations have been done due to improvement of activity data and corrected gasoline consumption in road transport |
| 4. Other sectors | $CH_4$ | 233.18 | 153.24 | -79.95 | -34.28 | -3.98 | -3.36 | Methodology change for biomass use in 1A4b sector (Tier 1 to Tier 2, using CS methane EFs), precised data for wood in 1A4a.<br>Diesel used for stationary and offroad installations were splitted in 1A4ci and 1A4cii. |
| **3. Agriculture** | $CH_4$ | 940.52 | 937.41 | -3.11 | -0.33 | -0.15 | -0.13 | |
| A. Enteric fermentation | $CH_4$ | 803.51 | 843.06 | 39.55 | 4.92 | 1.97 | 1.66 | The number of non-dairy cattle is split down in new 7 sub-groups by characterizing specifics of dairy and beef production. Reporting in CRF is performed for 3 cattle groups below Option: B. New sub-groups are defined by implementing research results under 2009 - 2014 EEA Grants Programme National Climate Policy Pre-Defined Project "Development of the National System for Greenhouse Gas Inventory and Reporting on Policies, Measures and Projections". Distribution of MMS is recalculated for all livestock groups due to application of new methodology developed under research results mentioned above. As share of pasture for cattle is changed, also feeding situation is described differently, |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | comparing to the previous submission. Cattle weight data are updated by national expert judgment based on Animal Breeders Association of Latvia Breeding Program results. Amount of milk production per day is adjusted to 305 lactation days. Deer is included in the inventory as a new animal category. |
| B. Manure management | $CH_4$ | 137.01 | 94.36 | -42.65 | -31.13 | -2.12 | -1.79 | For emissions calculation from manure management, also the number of swine is split down in 3 sub-groups and Tier 2 methodology is implemented to calculate methane emissions. Distribution of MMS is recalculated for all livestock groups due to application of new methodology developed under research results mentioned above. Also a new animal category as deer is included in the inventory. MCF value 2 for anaerobic digester is implemented in the inventory, according to TERT recommendations after the EU ESD voluntary review in 2015. |
| **4. Land use, land-use change and forestry (net) (4)** | $CH_4$ | 348.65 | 366.63 | 17.98 | 5.16 | | 0.76 | |
| A. Forestland | $CH_4$ | 141.81 | 146.61 | 4.80 | 3.39 | | 0.20 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| B. Cropland | $CH_4$ | 117.66 | 118.42 | 0.76 | 0.65 | | 0.03 | Revision of land use category due to manual check of land use categories entered in the NFI database. |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| C. Grassland | $CH_4$ | 60.65 | 73.06 | 12.41 | 20.47 | | 0.52 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| **5. Waste** | $CH_4$ | 736.76 | 793.26 | 56.50 | 7.67 | 2.81 | 2.38 | |
| A. Solid waste disposal | $CH_4$ | 532.90 | 522.65 | -10.26 | -1.92 | -0.51 | -0.43 | $CH_4$ emissions from Solid waste disposal were recalculated due to change of emission factor k and DOCf according to 2006 IPCC Guidelines. |
| B. Biological treatment of solid waste | $CH_4$ | 1.44 | 19.57 | 18.14 | 1262.30 | 0.90 | 0.76 | Recalculation is done due to new activity data estimation become available. Emissions from household composting are added to submission. For household composting emission factors for $CH_4$ were applied as for industrial composting. |
| D. Waste water treatment and discharge | $CH_4$ | 202.43 | 251.04 | 48.62 | 24.02 | 2.42 | 2.04 | Recalculated due to adjusted activity data both of Domestic and Industrial Waste Water Handling. |
| **International bunkers** | $CH_4$ | 1.38 | 1.26 | -0.12 | -8.48 | -0.01 | 0.00 | |
| Aviation | $CH_4$ | 0.23 | 0.12 | -0.12 | -49.98 | -0.01 | 0.00 | Recalculations have been done due to corrected number of LTO and fuel consumption for representative aircraft type in LTO cycle |
| | | | | | | | | |
| **1. Energy** | $N_2O$ | 120.22 | 137.91 | 17.70 | 14.72 | 0.95 | 0.69 | |
| A. Fuel combustion activities | $N_2O$ | 120.22 | 137.91 | 17.70 | 14.72 | 0.95 | 0.69 | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| 2. Manufacturing industries and construction | $N_2O$ | 19.78 | 19.93 | 0.15 | 0.78 | 0.01 | 0.01 | Precised amounts of anthracite and other biogas, recalculated waste amounts and emissions in 2013. |
| 3. Transport | $N_2O$ | 49.69 | 53.42 | 3.73 | 7.50 | 0.20 | 0.15 | Recalculations have been done due to improvement of activity data and corrected gasoline consumption in road transport |
| 4. Other sectors | $N_2O$ | 38.03 | 51.84 | 13.81 | 36.32 | 0.74 | 0.54 | EF change for biomass use in 1A4b sector (lowest values from $N_2O$ default EF range taken from 2006 IPCC Guidelines), precised data for wood in 1A4a.<br>Diesel used for stationary and offroad installations were splitted in 1A4ci and 1A4cii. |
| **2. Industrial processes and product use** | $N_2O$ | 0.01 | 1.95 | 1.95 | 36344.44 | 0.11 | 0.08 | |
| G. Other product manufacture and use | $N_2O$ | 0.01 | 1.95 | 1.95 | 36344.44 | 0.11 | 0.08 | During quality control procedures mistakes in $N_2O$ emission calculation were found. |
| **3. Agriculture** | $N_2O$ | 1351.75 | 1684.47 | 332.73 | 24.61 | 18.27 | 13.25 | |
| B. Manure management | $N_2O$ | 111.28 | 101.90 | -9.38 | -8.43 | -0.52 | -0.37 | Nitrogen excretion values are changed for poultry and swine as well as the amount of manure nitrogen that is lost due to volatilization of $NH_3$ and NOx is assigned to Tier 2 according to TERT recommendation after EU ESD voluntary review in 2015. A new animal category as deer is included in the inventory. |
| D. Agricultural soils | $N_2O$ | 1240.47 | 1582.58 | 342.11 | 27.58 | 18.78 | 13.62 | Recalculations are done due to the implementation of new emission factor for emission estimation from organic soils defined by |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement) methodological issues. This is done to reach consistent reporting of emissions with LULUCF sector. Updated organic soil areas are including in the inventory, based on information from LULUCF sector. Values of organic soils area are updated for 2009-2013. Dry matter fraction values and grassland area was updated for emission calculations from crop residue, based on the revision of current estimation and suggested technical corrections. Recalculations also are affected by implementation of new methodology to determine MMS and the share of grazing animals. |
| **4. Land use, land-use change and forestry (net)** | $N_2O$ | 698.84 | 690.61 | -8.23 | -1.18 | | -0.33 | |
| A. Forestland | $N_2O$ | 591.37 | 639.41 | 48.04 | 8.12 | | 1.91 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| B. Cropland | $N_2O$ | 22.57 | 5.19 | -17.38 | -77.00 | | -0.69 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| C. Grassland | $N_2O$ | 25.57 | 0.18 | -25.39 | -99.28 | | -1.01 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| D. Wetlands | $N_2O$ | 3.79 | 3.79 | 0.00 | 0.00 | | 0.00 | Revision of land use category due to manual check of land use categories entered in the NFI |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | database. |
| E. Settlements | $N_2O$ | 52.56 | 38.98 | -13.58 | -25.84 | | -0.54 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| **5. Waste** | $N_2O$ | 12.35 | 35.11 | 22.76 | 184.25 | 1.22 | 0.89 | |
| B. Biological treatment of solid waste | $N_2O$ | 1.28 | 14.00 | 12.71 | 989.84 | 0.68 | 0.50 | Recalculation is done due to new activity data estimation become available. Emissions from household composting are added to submission. For household composting emission factors for $N_2O$ were applied as for industrial composting. |
| D. Waste water treatment and discharge | $N_2O$ | 6.75 | 16.80 | 10.04 | 148.72 | 0.55 | 0.40 | Recalculated due to correction of mistake in applying emission factors |
| **International bunkers** | $N_2O$ | 36.52 | 36.14 | -0.38 | -1.04 | -0.02 | -0.02 | |
| Aviation | $N_2O$ | 4.40 | 4.03 | -0.38 | -8.61 | -0.02 | -0.02 | Recalculations have been done due to corrected number of LTO and fuel consumption for representative aircraft type in LTO cycle |

**Table 10.3 Recalculations made in 2016 submission (recalculated year 1990)**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| **1. Energy** | $CO_2$ | 18556.81 | 18610.70 | 53.89 | 0.29 | 0.27 | 0.52 | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| A. Fuel combustion activities | $CO_2$ | 18556.80 | 18610.69 | 53.89 | 0.29 | 0.27 | 0.52 | |
| 2. Manufacturing industries and construction | $CO_2$ | 3889.62 | 3883.95 | -5.67 | -0.15 | -0.03 | -0.05 | Amounts of coke previously reported in 1A2a sector are allocated to 2C1 sector. |
| 4. Other Sectors | $CO_2$ | 5535.58 | 5595.15 | 59.56 | 1.08 | 0.30 | 0.57 | Recalculations have been done in CRF 1.A.4.a sector due to activity data corrections. |
| **2. Industrial processes and product use** | $CO_2$ | 602.59 | 706.12 | 103.53 | 17.18 | 0.53 | 1.00 | |
| C. Metal industry | $CO_2$ | 12.82 | 52.60 | 39.78 | 310.39 | 0.20 | 0.39 | Recalculations have been done in all time series in sector 2.C.1 due to data of used carburizators (coke, coke fine etc.) are taken into account and allocated from Energy sector to IPPU. |
| D. Non-energy products from fuels and solvent use | $CO_2$ | 0.58 | 64.32 | 63.74 | 11071.60 | 0.32 | 0.61 | In 2015 submission indirect $CO_2$ emissions occuring in CRF 2.D.3 were reported outside of IPPU sector and reflected in Table 6. But in order to ensure compliance with the reporting done by Latvia under the first commitment period of the Kyoto Protocol, it was decided the indirect $CO_2$ emissions from NMVOCs in solvent use, road paving with asphalt, asphalt roofing and glass fibre production to report under CRF 2.D.3. In 2015/2016 recalculations for period 1990-2014 have been carried out under Solvent Use sector due the corrected list of NMVOCs substances and change of method for all time series in accordance with EMEP/EEA 2013 for all time series (see Chapter 4.5.3.2.). Also recalculations were made in 2.D.1 and 2.D.2 |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | sectors due to correction of mistake in calculation which affects $CO_2$ emissions in all time series. |
| **4. Land use, land-use change and forestry (net) (4)** | $CO_2$ | -9782.42 | -9305.34 | 477.08 | -4.88 | | 4.62 | |
| A. Forestland | $CO_2$ | -15040.33 | -14661.36 | 378.97 | -2.52 | | 3.67 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| B. Cropland | $CO_2$ | 3249.06 | 3293.67 | 44.61 | 1.37 | | 0.43 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| C. Grassland | $CO_2$ | 851.29 | 901.37 | 50.08 | 5.88 | | 0.48 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| D. Wetlands | $CO_2$ | 1215.01 | 1215.01 | 0.00 | 0.00 | | 0.00 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| E. Settlements | $CO_2$ | 108.91 | 112.33 | 3.42 | 3.14 | | 0.03 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| **Indirect $CO_2$** | $CO_2$ | 142.11 | 43.43 | -98.68 | -69.44 | -0.50 | -0.96 | In 2015 submission indirect $CO_2$ emissions occuring in CRF 2.D.3 were reported outside of IPPU sector (under Indirect $CO_2$) and reflected in Table 6. But in order to ensure compliance with the reporting done by Latvia under the first commitment period of the Kyoto Protocol, it was decided the indirect $CO_2$ emissions from NMVOCs in solvent use, road paving with asphalt, asphalt roofing and glass fibre production to report under CRF 2.D.3. |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| **1. Energy** | $CH_4$ | 552.72 | 498.50 | -54.22 | -9.81 | -1.48 | -1.36 | |
| A. Fuel combustion activities | $CH_4$ | 305.14 | 250.92 | -54.22 | -17.77 | -1.48 | -1.36 | |
| 2.Manufacturing industries and construction | $CH_4$ | 5.48 | 5.48 | 0.00 | -0.02 | 0.00 | 0.00 | Amounts of coke previously reported in 1A2a sector are allocated to 2C1 sector. |
| 4. Other sectors | $CH_4$ | 275.07 | 220.85 | -54.22 | -19.71 | -1.48 | -1.36 | Methodology change for biomass use in 1A4b sector (Tier 1 to Tier 2, using CS methane EFs), precised data for wood in 1A4a.<br>Recalculations have been done in CRF 1.A.4.a sector due to activity data corrections.<br>Diesel used for stationary and offroad installations were splitted in 1A4ci and 1A4cii. |
| **3. Agriculture** | $CH_4$ | 2690.49 | 2411.15 | -279.33 | -10.38 | -7.63 | -7.04 | |
| A. Enteric fermentation | $CH_4$ | 2281.89 | 2221.54 | -60.35 | -2.64 | -1.65 | -1.52 | The number of non-dairy cattle is split down in new 7 sub-groups by characterizing specifics of dairy and beef production. Reporting in CRF is performed for 3 cattle groups below Option: B. New sub-groups are defined by implementing research results under 2009 - 2014 EEA Grants Programme National Climate Policy Pre-Defined Project "Development of the National System for Greenhouse Gas Inventory and Reporting on Policies, Measures and Projections".<br>Distribution of MMS is recalculated for all livestock groups due to application of new methodology developed under research results |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | mentioned above. As share of pasture for cattle is changed, also feeding situation is described differently, comparing to the previous submission. Cattle weight data are updated by national expert judgment based on Animal Breeders Association of Latvia Breeding Program results. Amount of milk production per day is adjusted to 305 lactation days. Deer is included in the inventory as new animal category. |
| B. Manure management | $CH_4$ | 408.59 | 189.61 | -218.98 | -53.59 | -5.98 | -5.52 | For emissions calculation from manure management, also the number of swine is split down in 3 sub-groups and Tier 2 methodology is implemented to calculate methane emissions. Distribution of MMS is recalculated for all livestock groups due to application of new methodology developed under research results mentioned above. Also a new animal category as deer is included in the inventory. MCF value 2 for anaerobic digester is implemented in the inventory, according to TERT recommendations after EU ESD voluntary review in 2015. |
| **4. Land use, land-use change and forestry (net) (4)** | $CH_4$ | 303.72 | 307.53 | 3.81 | 1.25 | | 0.10 | |
| A. Forestland | $CH_4$ | 83.84 | 83.86 | 0.01 | 0.01 | | 0.00 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| B. Cropland | $CH_4$ | 125.09 | 125.10 | 0.00 | 0.00 | | 0.00 | Revision of land use category due to manual check of land use categories entered in the NFI database. |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| C. Grassland | $CH_4$ | 66.25 | 70.04 | 3.79 | 5.72 | | 0.10 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| **5. Waste** | $CH_4$ | 752.66 | 761.54 | 8.88 | 1.18 | 0.24 | 0.22 | |
| B. Biological treatment of solid waste | $CH_4$ | NO,NE | 23.91 | 23.91 | 100.00 | 0.65 | 0.60 | Recalculation is done due to new activity data estimation become available. Emissions from household composting are added to submission. For household composting emission factors for $CH_4$ were applied as for industrial composting. |
| D. Waste water treatment and discharge | $CH_4$ | 359.83 | 344.80 | -15.03 | -4.18 | -0.41 | -0.38 | Recalculation due to changed methodology and adjustment of assumptions and MCFs for Domestic Waste Water Handling. |
| | | | | | | | | |
| **1. Energy** | $N_2O$ | 148.93 | 174.39 | 25.46 | 17.10 | 0.88 | 0.73 | |
| A. Fuel combustion activities | $N_2O$ | 148.93 | 174.39 | 25.46 | 17.10 | 0.88 | 0.73 | |
| 2.Manufacturing industries and construction | $N_2O$ | 8.79 | 8.77 | -0.02 | -0.27 | 0.00 | 0.00 | Amounts of coke previously reported in 1A2a sector are allocated to 2C1 sector. |
| 4. Other sectors | $N_2O$ | 48.49 | 73.98 | 25.49 | 52.55 | 0.88 | 0.74 | EF change for biomass use in 1A4b sector (lowest values from N2O default EF range taken from 2006 IPCC Guidelines), precised data for wood in 1A4a.<br>Recalculations have been done in CRF 1.A.4.a sector due to activity data corrections.<br>Diesel used for stationary and offroad installations were splitted in 1A4ci and 1A4cii. |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| **2. Industrial processes and product use** | $N_2O$ | 0.00 | 1.30 | 1.30 | 27212.50 | 0.05 | 0.04 | |
| G. Other product manufacture and use | $N_2O$ | 0.00 | 1.30 | 1.30 | 27212.50 | 0.05 | 0.04 | During quality control procedures mistakes in $N_2O$ emission calculation were found. |
| **3. Agriculture** | $N_2O$ | 2489.05 | 2663.75 | 174.70 | 7.02 | 6.15 | 5.11 | |
| B. Manure management | $N_2O$ | 305.42 | 323.75 | 18.33 | 6.00 | 0.65 | 0.54 | Nitrogen excretion values are changed for poultry and swine according to ERT review results. The amount of manure nitrogen that is lost due to volatilization of $NH_3$ and NOx is assigned to Tier 2 approach, according to TERT suggestion after EU ESD voluntary review in 2015. A new animal category as deer is included in the inventory. |
| D. Agricultural soils | $N_2O$ | 2183.63 | 2340.00 | 156.37 | 7.16 | 5.51 | 4.58 | Recalculations are done due to the implementation of new emission factor for emission estimation from organic soils defined by 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement) methodological issues. This is done to reach consistent reporting of emissions with LULUCF sector. Updated organic soil areas are including in the inventory, based on information from LULUCF sector. Values of organic soils area are updated for 2009-2013. Dry matter fraction values and grassland area was updated for emission calculations from crop residue, based on the revision of current estimation and suggested technical corrections. Recalculations also are affected by |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | implementation of new methodology to determine MMS and the share of grazing animals. |
| **4. Land use, land-use change and forestry (net)** | $N_2O$ | 579.20 | 576.18 | -3.02 | -0.52 | | -0.09 | |
| A. Forestland | $N_2O$ | 571.13 | 570.67 | -0.46 | -0.08 | | -0.01 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| B. Cropland | $N_2O$ | 3.15 | 0.59 | -2.56 | -81.26 | | -0.07 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| C. Grassland | $N_2O$ | 0.05 | 0.05 | 0.00 | -0.27 | | 0.00 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| D. Wetlands | $N_2O$ | 3.79 | 3.79 | 0.00 | 0.00 | | 0.00 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| E. Settlements | $N_2O$ | 0.91 | 0.91 | 0.00 | 0.00 | | 0.00 | Revision of land use category due to manual check of land use categories entered in the NFI database. |
| **5. Waste** | $N_2O$ | 11.12 | 48.98 | 37.86 | 340.50 | 1.31 | 1.09 | |
| B. Biological treatment of solid waste | $N_2O$ | NO,NE | 17.10 | 17.10 | 100.00 | 0.59 | 0.49 | Recalculation is done due to new activity data estimation become available. Emissions from household composting are added to submission. For household composting emission factors for $N_2O$ were applied as for industrial composting. |
| D. Waste water treatment and discharge | $N_2O$ | 6.27 | 27.03 | 20.76 | 331.00 | 0.73 | 0.61 | Recalculated due to correction of mistake in applying emission factors. |

**Table 10.4 Recalculations made in 2016 submission (F-gases) (recalculated year 2013)**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| **F-gases: Total actual Emissions** | HFCs | 108.46 | 204.35 | 95.90 | 88.42 | 46.93 | 46.93 | |
| 2.F.1. Refrigeration and air conditioning | HFCs | 102.86 | 198.93 | 96.07 | 93.40 | 47.01 | 47.01 | Recalculations were made in all 2.F. subcategories due to implementation of F-gases research (2016) results. According to the research, activity data taken from annual reports by F-gases operators were split between the subcategories and the time series was recalculated at a level of 2006 IPCC Guidelines subcategories (Commercial, Industrial, Transport refrigeration and Stationary air conditioning). Emission factors were elaborated based on consultations with Latvian Freezing Equipment Engineers` Association.<br>Recalculations were made also for mobile air conditioners as more precise data regarding population of cars and distribution by vehicle types (passenger cars, LDV, HDV), age and vehicle categories according to emission control system (EURO classes) were obtained.<br>Refrigerant stocks and emissions from operating systems in 2.F.1 were recalculated due to recommendation by TERT during EU ESD review in 2016. |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| 2.F.2. Foam blowing agents | HFCs | 0.00 | 1.84 | 1.84 | 128441.47 | 1.41 | 1.41 | Emissions from foaming of polyether (for shoe soles) were added to 2.F.2 Closed cell foams after recommendation by TERT during EU ESD voluntary review in 2015. Consequently emissions from 2.F.2 Foam Blowing Products increased. |
| 2.F.3. Fire protection | HFCs | 0.24 | 0.06 | -0.17 | -73.83 | -0.13 | -0.13 | Emissions have decreased due to decrease of activity data reported in annual reports by companies using F gases in Fire protection equipment. |
| 2.G.4. Other | HFCs | 1.84 | NO | -1.84 | -100.00 | -1.41 | -1.41 | Emissions from foaming of polyether (for shoe soles) previously wrongly reported under 2.G.4 Other. After recommendation by TERT during EU ESD voluntary review in 2015, these emissions included under 2.F.2 Foam Blowing Products. |

**Table 10.5 Recalculations made in 2016 submission (F-gases) (recalculated year 1995)**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF(3) % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| **F-gases: Total actual Emissions** | HFC | 0.67 | 11.50 | 10.83 | 1617.59 | 94.18 | 94.18 | |
| 2.F.1. Refrigeration and air conditioning | HFCs | 0.27 | 11.10 | 10.83 | 4022.43 | 94.18 | 94.18 | Recalculations were made in all 2.F. subcategories due to implementation of F-gases research (2016) results. According to the research, activity data taken from annual reports by F-gases operators were split between the |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Gas | Previous submission ($CO_2$-eq, kt) | Latest submission ($CO_2$-eq, kt) | Difference ($CO_2$-eq, kt) | Difference % | Impact of recalculation on total emissions excluding LULUCF % | Impact of recalculation on total emissions including LULUCF(3) % | Explanation for recalculations |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | subcategories and the time series was recalculated at a level of 2006 IPCC Guidelines subcategories (Commercial, Industrial, Transport refrigeration and Stationary air conditioning). Emission factors were elaborated based on consultations with Latvian Freezing Equipment Engineers` Association.<br>Recalculations were made also for mobile air conditioners as more precise data regarding population of cars and distribution by vehicle types (passenger cars, LDV, HDV), age and vehicle categories according to emission control system (EURO classes) were obtained. |
| 2.F.2. Foam blowing agents | HFC | NO,NE | 0.40 | 0.40 | 100.00 | 3.48 | 3.48 | Emissions from foaming of polyether (for shoe soles) was added to 2.F.2 Closed cell foams after recommendation by TRT during EU ESD voluntary review in 2015. Consequently emissions from 2.F.2 Foam Blowing Products increased. |
| 2.G.4. Other | HFC | 0.40 | NO | -0.40 | -100.00 | -3.48 | -3.48 | Emissions from foaming of polyether (for shoe soles) previously wrongly reported under 2.G.4 Other. After recommendation by TERT during EU ESD voluntary review in 2015, these emissions included under 2.F.2 Foam Blowing Products. |

Changes in methodological descriptions for 2016 submission are summarized in Table 10.6 below.

**Table 10.6 Changes in methodological descriptions**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | DESCRIPTION OF METHODS | RECALCULATIONS | REFERENCE |
|---|---|---|---|
| | **Please mark the relevant cell where the latest NIR includes major changes in methodological descriptions compared to the NIR of the previous year** | **Please mark the relevant cell where this is also reflected in recalculations compared to the previous years' CRF** | **If the cell is marked please provide a reference to the relevant section or pages in the NIR and if applicable some more detailed information such as the sub-category or gas concerned for which the description was changed.** |
| **Total (Net Emissions)** | - | - | - |
| **1. Energy** | - | - | - |
| A. Fuel Combustion (sectoral approach) | - | - | - |
| 1. Energy industries | - | - | - |
| 2. Manufacturing industries and construction | - | - | - |
| 3. Transport | - | - | - |
| 4. Other sector | **+** | **+** | Change from Tier 1 to Tier 2 in 1.A.4.b. (for $CH_4$). More information available on NIR chapter 3.2.7.2. |
| 5. Other | - | - | - |
| B. Fugitive emissions from fuels | - | - | - |
| 1. Solid fuels | - | - | - |
| 2. Oil and natural gas and other emissions from energy production | - | - | - |
| C. $CO_2$ transport and storage | - | - | - |
| **2. Industrial processes and product use** | - | - | - |
| A. Mineral industry | - | - | - |
| B. Chemical industry | - | - | - |
| C. Metal industry | - | - | - |
| D. Non-energy products from fuels and solvent use | **+** | **+** | 2.D.3, Solvent Use, see Chapter 4.5.3.6. |
| E. Electronic industry | - | - | - |
| F. Product uses as substitutes for ODS | **+** | **+** | 2.F.1 Refrigeration and Air Conditioning, see Chapter 4.7.1. |
| G. Other product manufacture and use | **+** | **+** | 2.G.3, $N_2O$ From Product Uses, see Chapter 4.8.2.6. |
| H. Other | - | - | - |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | DESCRIPTION OF METHODS | RECALCULATIONS | REFERENCE |
|---|---|---|---|
| | **Please mark the relevant cell where the latest NIR includes major changes in methodological descriptions compared to the NIR of the previous year** | **Please mark the relevant cell where this is also reflected in recalculations compared to the previous years' CRF** | **If the cell is marked please provide a reference to the relevant section or pages in the NIR and if applicable some more detailed information such as the sub-category or gas concerned for which the description was changed.** |
| **3. Agriculture** | - | - | - |
| A. Enteric fermentation | - | - | - |
| B. Manure management | - | - | - |
| C. Rice cultivation | - | - | - |
| D. Agricultural soils | - | - | - |
| E. Prescribed burning of savannahs | - | - | - |
| F. Field burning of agricultural residues | - | - | - |
| G. Liming | - | - | - |
| H. Urea application | - | - | - |
| I. Other carbon containing fertilisers | - | - | - |
| J. Other | - | - | - |
| **4. Land use, land-use change and forestry** | - | - | - |
| A. Forest land | - | **+** | Described in the NIR section 7.6 Forest land, sub-section 7.6.7 Category-specific recalculations |
| B. Cropland | - | **+** | Described in the NIR section 7.7 Cropland, sub-section 7.7.1.7 and 7.7.2.7 Category-specific recalculations |
| C. Grassland | - | **+** | Described in the NIR section 7.8 Grassland, sub-section 7.8.1.6 and 7.8.2.6 Category-specific recalculations |
| D. Wetlands | - | **+** | Described in the NIR section 7.9 Wetland, sub-section 7.9.7 Category-specific recalculations |
| E. Settlements | - | **+** | Described in the NIR section 7.10 Settlements, sub-section 7.10.8 Category-specific recalculations |
| F. Other land | - | **-** | - |
| G. Harvested wood products | - | **+** | Described in the NIR section 7.13 Harvested wood products, sub-section 7.13.7 Category-specific recalculations |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | DESCRIPTION OF METHODS | RECALCULATIONS | REFERENCE |
|---|---|---|---|
| | **Please mark the relevant cell where the latest NIR includes major changes in methodological descriptions compared to the NIR of the previous year** | **Please mark the relevant cell where this is also reflected in recalculations compared to the previous years' CRF** | **If the cell is marked please provide a reference to the relevant section or pages in the NIR and if applicable some more detailed information such as the sub-category or gas concerned for which the description was changed.** |
| H. Other | - | - | - |
| **5. Waste** | - | - | - |
| A. Solid waste disposal | - | - | - |
| B. Biological treatment of solid waste | **+** | **+** | Changes in composting activity data. Amount if compotsed amounts from households are firstly estimated from year 1990. |
| C. Incineration and open burning of waste | - | - | - |
| D. Wastewater treatment and discharge | | **+** | NIR Chapter 7.5.1.5. and 7.5.2.5. N2O emissions from Domestic Waste Water Handling recalculated for entire period due to correction of mistake with Efs; $CH_4$ emissions from Domestic Waste Water Handling recalculated for period 2000 - 2013 due to adjustment of activity data; $CH_4$ emissions from Industrial Waste Water Handling recalculated for period 2000 - 2013 due to adjustment of activity data. |
| E. Other | - | - | - |
| **6. Other (as specified in Summary 1.A)** | - | - | - |
| **KP LULUCF** | - | - | - |
| **Article 3.3 activities** | -- | - | - |
| Afforestation/reforestation | **+** | **+** | Described in the NIR section 12.KP-LULUCF, sub-section 12.3.1.4 Changes in data and methods since the previous submission (recalculations) |
| Deforestation | **+** | **+** | Described in the NIR section 12.KP-LULUCF, sub-section 12.3.1.4 Changes in data and methods since the previous submission (recalculations) |
| **Article 3.4 activities** | - | **-** | - |

| **GREENHOUSE GAS SOURCE AND SINK CATEGORIES** | **DESCRIPTION OF METHODS** | **RECALCULATIONS** | **REFERENCE** |
|---|---|---|---|
| | **Please mark the relevant cell where the latest NIR includes major changes in methodological descriptions compared to the NIR of the previous year** | **Please mark the relevant cell where this is also reflected in recalculations compared to the previous years' CRF** | **If the cell is marked please provide a reference to the relevant section or pages in the NIR and if applicable some more detailed information such as the sub-category or gas concerned for which the description was changed.** |
| Forest management | **+** | **+** | Described in the NIR section 12.KP-LULUCF, sub-section 12.3.1.4 Changes in data and methods since the previous submission (recalculations) |
| Cropland management (if elected) | - | **-** | - |
| Grazing land management (if elected) | - | **-** | - |
| Revegetation (if elected) | - | **-** | - |
| Wetland drainage and rewetting (if elected) | - | - | - |
| **NIR Chapter** | **DESCRIPTION** | | **REFERENCE** |
| | **Please mark the cell where the latest NIR includes major changes in descriptions compared to the previous year NIR** | | **If the cell is marked please provide some more detailed information for example reference to pages in the NIR** |
| **Chapter 1.2 Description of national inventory arrangements** | - | - | - |

### 10.1.2 KP-LULUCF inventory

Deforestation in 2009-2013 is recalculated by application of updated land use data provided by the NFI after spatial analysis of the NFI plots. In previous inventory reports extrapolation of historical data and results of remote sensing analysis were used. This recalculation considerably increased emissions due to deforestation and from organic soils.

## *10.2 Implication for emission levels*

### 10.2.1 GHG inventory

See section 10.1.

### 10.2.2 KP-LULUCF inventory

Recalculations reduced net removals in 1990-2013 in the KP-LULUCF inventory by 5%; however, the most of the impact applies to period from 2009 to 2013 for which new data on deforestation are applied.

## *10.3 Implications for emission trends, including time series' consistency*

### 10.3.1 GHG inventory

See section 10.1.

### 10.3.2 KP-LULUCF inventory

See section 10.1

## *10.4 Recalculations, including in response to the review process, and planned improvements to the inventory*

### 10.4.1 GHG inventory

The development of the GHG inventory aims to improve the calculation and reporting of the inventory. The improvement plan is discussed and approved by all experts and organizations involved in GHG inventory preparation process.

Many improvements of next and future GHG inventories are planned within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy ":

- ) development of an integrated database for climate change and air quality data aggregation. The development of the database will result in enhanced data quality, workflow optimization and facilitation of report submissions;

-) preparation of research studies for GHG inventory improving (for example, Promoting sustainable land management through creation of a digital soil database; analyze bovine intestinal fermentation processes (methane release); evaluate agricultural fertilizer-related processes and activities; estimation of soil carbon stock in cropland and grassland);

Table 10.7 shows the sector specific improvements needs for the forthcoming inventories. More detailed information about planned improvements can be found under sectoral chapters.

**Table 10.7 Sector specific planned improvements for Latvia`s national GHG inventory**

| | Planned improvement | Tentative time schedule | Progress |
|---|---|---|---|
| General | Develop an integrated database for climate change and air quality data aggregation and preparation of GHG inventory (NIR) and other reports to different international institutions. | From 2017 | Implementation of integrated database is ongowing in 2016. Launching of system is planned in 2017. |
| General | Improve uncertainty of the inventory | 2016 | Experience sharing seminar regarding uncertainty |

| | Planned improvement | Tentative time schedule | Progress |
|---|---|---|---|
| | | | evaluation already took place at the end of 2015 within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy ". As a result uncertainty evaluation was improved and overall uncertainty of the 2016 submission has significantly reduced compared to previous submissions. Implementation of final results is ongoing. |
| IPPU/F-gases | Elaborate F-gases reporting – improve AD obtaining, develop country specific emission factors, improve QA/QC procedures of F-gases inventory | 2015-2017 | Started in 2015 within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy ". Results implemented into this submission. Additional cross-checks with data reported under Regulation EU 517/2014 are planned for the next submission. |
| 2.D.3 Solvent Use | Electronic reporting for importers and producers in the Chemicals Register. | 2016-2017 | It is planned to implement electronic reporting for importers and producers in the Chemicals Register. According to that, possible changes in activity data are expected. It is planned to get more accurate division by subcategories taking into account that previously it was done by expert judgment. |
| Agriculture 3.A.1 Enteric fermentation | Updating of digestible energy as percent of gross energy for cattle, according to feeding situation research | 2017 | Improvement planned within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy ". |

| | Planned improvement | Tentative time schedule | Progress |
|---|---|---|---|
| Agriculture 3.A.2. Manure management | Implementation of country specific nitrogen excretion values for all livestock groups based on latest research activities.<br>Revision of MCF value for anaerobic digester, based on data collection and proceeding required by ERT in 2015. | 2017 | Improvement planned within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy". |
| Agriculture 3.A.2. Manure management | Strengthening Tier 2 methodology for indirect emissions calculations from manure management to force development of national ammonia model. Straitening the consistency of GHG and ammonia emissions reporting. | 2017-2018 | Improvement planned within activities supported by funding of Ministry of Environmental Protection and Regional Development. |
| Agriculture 3.D | Future development of the country specific value for FracLEACH-(H) and FRACGASM to estimate N losses by leaching/runoff and volatilization. | 2017-2018 | Improvement planned within activities of GHG research group of Latvia University of Agriculture. |
| LULUCF - overview | Evaluation of carbon stock changes in croplands and grasslands. | 2016 | Improvement planned within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy ". Field data collection and analyses are done, scientific publication is under preparation. After publishing the results will be implemented in the GHG calculations. |
| LULUCF Direct and Indirect $N_2O$ emissions from managed soils | $N_2O$ emissions might be considerable part of emissions from wetlands, therefore, it is necessary to develop method for estimation impact of drainage on $N_2O$ emissions, and it is important to be able to separate wetlands on nutrients rich organic soils (high $N_2O$ emissions) and poor organic | 2016-2020 | Demonstration project application for LIFE+ program "LIFE Restore - Support tools for sustainable and responsible management and re-use of degraded peatlands in Latvia" proposed in 2015. The project is started in September, 2015 and |

| | Planned improvement | Tentative time schedule | Progress |
|---|---|---|---|
| | soils (low $N_2O$ emissions). Information on land use changes, particularly, distribution of nutrients rich and poor organic and losses of organic carbon due to land use changes should be updated. Country specific C/N ratio will be introduced for calculation of $N_2O$ emissions from forest land, cropland and grassland in 2017. | | the outputs (emission factors) will be available in 2019. |
| LULUCF 4.A Forest Land | Estimation of decay period for dead wood (harvesting residues and below-ground biomass, planned to complete until report 1990-2014); | 2016 | Research project on this issue is completed, implementation stage is proposed in 2015. The results will be used in the GHG calculations after publishing results. |
| | Estimation of carbon stock changes in drained organic soils in forest lands (2015); | 2016 | The research completed for fertile organic soils and emission factors are elaborated; scientific publication is under preparation and will be delivered to peer reviewed magazine. |
| | Development of production version of EPIM tool, including broader representation of land use change, integration of land use change and GHG calculation modules and integration of Kyoto protocol and the UNFCCC reporting modules. | 2016 | Technical work and quality assurance still ongoing in 2016. |
| LULUCF 4.B.1 Cropland remaining cropland | Updated area of organic soil in cropland according to the NFI study started in 2012 and soil mapping project. | 2016-2020 | Temporary results will be available in 2016 after completion of soil mapping project, all NFI plots on former and currently used cropland and grassland on organic soils will be visited until 2017, and final reporting will be done in 2017. |
| | Updated $CO_2$ emissions from organic soil considering area changes and recent findings in Nordic and Baltic countries, particularly, doctoral thesis by Jüri-Ott Salm "Emission of greenhouse gases $CO_2$, $CH_4$, and $N_2O$ from Estonian transitional fens and ombrotrophic bogs: the impact of different land-use practice". | 2016-2020 | Demonstration project application for LIFE+ program "LIFE Restore - Support tools for sustainable and responsible management and re-use of degraded peatlands in Latvia" is started in 2015, updated emission factors will be available in 2019. |
| | Tier 3 methodology to estimate carbon | 2017 | It is proposed to implement |

| | Planned improvement | Tentative time schedule | Progress |
|---|---|---|---|
| | stock changes in cropland considering changes of cropping practices since 1970. | | Yasso model in forest land and cropland to obtain information on carbon stock changes in soil, the implementation is planned in 2017, forest lands on dry mineral soils, cropland and grassland will be covered by the estimation. Results should be prepared for publication until the end of 2017. |
| LULUCF 4.B.2 Land converted to cropland | Area of organic soil might be overestimated in land converted to cropland. Field measurement based information on organic soils is necessary to improve accuracy of estimates of the emissions. | 2016 | The new estimates will be based on soil mapping project, which has to be completed in 2016, and GIS analysis of land use changes in the NFI plots. The work is ongoing; however, due to limited capacity, it will be implemented in the GHG inventory in 2017. |
| LULUCF 4.C Grasslands | Improvement of reporting for ditch area in organic soil. Now the estimates are based on limited knowledge about organic soils and drainage ditches in grasslands. The updated information will be based on NFI data, soil mapping data and digital GIS information on drainage systems. | 2016 | Soil mapping project has to be completed to start estimation of area of drainage ditches on organic soils. |
| LULUCF 4.B., 4.C. Land, Aggregate Sources and Non-$CO_2$ EmissionsSources on Land | Create a digital database of soils digitalising available soil maps. | 2016 | Is under implementation within the scope of the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy ". |
| LULUCF 4.B.5. Settlements | Utilization of high resolution satellite images to evaluate dynamics of carbon stock in living biomass in certain pilot areas since 1990 and to extrapolate obtained results to all NFI plots to avoid potential overestimation of removals of $CO_2$ in living biomass. | 2016-2020 | Planned to implement in following submissions. |
| LULUCF 4 (V) Biomass Burning | A new methodology on estimation of incineration efficiency in forest fires will be elaborated and different types of forest fires will be separated to account the GHG emissions more accurate. Information provided by the State forest service will be used with | 2017 | The work plan is elaborated for implementation to obtain data for the following inventories. |

| | Planned improvement | Tentative time schedule | Progress |
|---|---|---|---|
| | higher level of accuracy by splitting different types of forest fires and following activities in the forest stands to avoid double reporting of harvested wood extracted in sanitary felling after forest fires. Burning of harvesting residues will be evaluated by forest owner's questionnaires. | | |
| Waste 5.A Solid Waste Disposal | Estimation of MCF will be done for Latvia landfills for all time series. | 2015-2016 | It is planned to make an efforts within the programme "European Economic Area Financial Mechanism 2009-2014 – "National Climate Policy" to improve MCF uses. Research about MCF and $CH_4$ content in landfill gas was done in year 2015. Results of the research are in the evaluation stage. Emission calculation improvement will be undertaken for next submission. |
| Waste 5.B.1 Composting | New waste recovery classification in Latvia comes in force in 2013. Determination of composting will be more precise, because special R code will be used for composting.<br>It is planned to make an efforts within the programme "European Economic Area Financial Mechanism 2009-2014 – "National Climate Policy" to improve this section. Research about composted amounts in households and country specific emissions factors for composting will be realized in year 2015. | 2015-2016 | It is planned to organize the pilot project within the programme "European Economic Area Financial Mechanism 2009-2014 – "National Climate Policy". Improvement will be undertaken for next submission. |
| Waste 5.D Waste Water Handling | Further assessment of sewage sludge properties depending of content of dry solids to distinct anaerobic sewage sludge from dry sewage sludge, stored in piles. | 2016-2017 | On-site visits to sewage sludge treatment plants are planned. |

Response to the review (Table 10.8) includes:

- recommendations related to Supplementary Information required under Article 7, Paragraph 1 of the Kyoto Protocol listed in Report on the individual review of the annual submission of Latvia submitted in 2014[254];

[254] *http://unfccc.int/resource/docs/2015/arr/lva.pdf*

- recommendations in LULUCF and KP-LULUCF sectors during the international third part review in 2015;

**Table 10.8 Response to the review process**

| Sector | CRF Category/ Issue | Review Recommendation | Review Report/ Paragraph | LV Response (status of implementation) | Chapter/Section in the NIR |
|---|---|---|---|---|---|
| Article 3, paragraphs 3 and 4, of the Kyoto Protocol | General | Use updated data from the second cycle of the NFI to calculate more reliable estimates of the areas converted to forest land in the period 2008–2012 | FCCC/ARR/ 2014/LV, para 95 | Recalculation of areas is done according to recommendations of ERT; however, more accurate estimation of area of afforested lands is targeted in the improvement plan to consider also natural regeneration as a forest management method | Chapter 11, Section 11.3. |
| KP-LULUCF | Afforestation and reforestation – $CO_2$ | Provide figures that demonstrate no statistically significant difference in the carbon stock in mineral soils in historical grassland and afforested land | FCCC/ARR/ 2014/LV, para 100 | Field data collection and analyses are done. Preliminary data on carbon stock in grassland and forest land are published by: Lazdiņš, A., Bārdule, A. & Butlers, A. (2015). Preliminary results of comparison of carbon stock in soil in grassland, cropland and forest land. *Proceedings of Adaptation and mitigation: strategies for management of forest ecosystems*, Airport hotel ABC, 2015. pp 54–57.<br>Lazdiņš, A., Bārdule, A. & Stola, J. (2013). Preliminary results of evaluation of carbon stock in historical cropland and grassland. *Proceedings of Interdisciplinary Research for Higher Socioeconomic Value of Forests*, Riga, 2013. pp 56–57. LSFRI Silava. Scientific publication that highlight final conclusions is under preparation. After publishing the results will be implemented in the GHG calculations. | Chapter 11, Section 11.3. |
| KP-LULUCF | Afforestation and reforestation – $CO_2$ | Include the explanation provided to the ERT on the reasons for reporting the carbon stock changes in above- and below-ground biomass as "NO" | FCCC/ARR/ 2014/LV, para 101 | Carbon stock changes in above and below-ground biomass are recalculated according to updated information provided by the NFI. NO is not any more used for carbon stock changes in living biomass in afforested land | Chapter 11, Section 11.3 |

| Sector | CRF Category/ Issue | Review Recommendation | Review Report/ Paragraph | LV Response (status of implementation) | Chapter/Section in the NIR |
|---|---|---|---|---|---|
| KP-LULUCF | Deforestation – $CO_2$ | Include the specific exclusions in the definition of forest and any other criteria provided in the NIR | FCCC/ARR/ 2014/LV, para 104 | Information about principles of estimation of land use changes are provided in relevant chapters of forest land, cropland and grassland with following cross-references to this information in KP 3.3 activities related chapters | Chapter 11, Section 13.2 |
| KP-LULUCF | Deforestation – $CO_2$ | Provide adequate documentation to support the expert judgement applied to separate emissions from living biomass due to commercial harvesting following deforestation | FCCC/ARR/ 2014/LV, para 105 | Emissions due to commercial felling before deforestation are accounted as losses of living biomass due to deforestation | Chapter 13, Section 11.2 |
| KP-LULUCF | Forest management – $CO_2$ | Include the information provided in the annex to the response from Latvia "Afforestation study_SP" that justifies the recalculated areas meet the requirements of definitions in decision 16/CMP.1 in the NIR | FCCC/ARR/ 2014/LV, para 106 | Detailed information on reporting of land under afforestation is provided in relevant sections of NIR (land converted to forest and relevant sections in the National inventory report on reporting of KP 3.3 activities | Chapter 11, Section 11.2 and 11.3 |
| KP-LULUCF | Forest management – $CO_2$ | Report the carbon losses due to harvesting that took place on afforested/reforested areas and on forest management separately and report this issue transparently | FCCC/ARR/ 2014/LV, para 108 | As it is noted in the NIR, there is no evidences of commercial felling in afforested lands according to NFI data. Losses of biomass due to pre-commercial thinning are reported under natural mortality and carbon stock changes in dead biomass | Chapter 11, Section 11.3 |
| KP-LULUCF | Biomass burning – $CO_2$ | Include the explanation regarding the use of the notation key "IE" to report $CO_2$ emissions from controlled burning | FCCC/ARR/ 2014/LV, para 109 | Detailed explanation is provided in sub-chapter of methodologic issues under chapter Biomass burning | Chapter 6, Section 6.10 |

| Sector | CRF Category/ Issue | Review Recommendation | Review Report/ Paragraph | LV Response (status of implementation) | Chapter/Section in the NIR |
|---|---|---|---|---|---|
| Standard electronic format and reports from the national registry | National Registry | Address the recommendations contained in the SIAR. | FCCC/ARR/ 2014/LV, para 110 | Recommendations contained in the SIAR addressed in this submission. | Chapter 14 |
| | National Registry | Clarify what changes have been made to the national registry. | FCCC/ARR/ 2014/LV, para 119 | Information regarding changes in national registry provided in this submission. | Chapter 14 |
| | National Registry | Include all other additional information in response to the SIAR findings in the NIR in accordance with decision 15/CMP.1 | FCCC/ARR/ 2014/LV, para 120 | All information in response to the SIAR findings are included in the NIR in accordance with decision 15/CMP.1 | Chapter 14 |
| Cross-sectoral | General | Clarify all reporting requirements and identify best data available in the country or internationally (e.g. Joint Research Centre, Food and Alimentation Organization, etc.), while having in mind low cost solutions. International data can be used as surrogate until national better data is achieved | LULUCF, KP-LULUCF third part review[255] | Latvian State Forest Research Institute Silava is continuously involved in several international and national scientific projects to develop and evaluate country specific emission factors and more accurate activity data. Several scientific publication is under preparation. After publishing the results will be implemented in the GHG calculations. There is good cooperation practice with NFI, State forest service and other organization that provide the most updated data used in GHG calculations. | Chapter 6 and Chapter 11 |

[255] *Third part review of Latvia's GHG inventory from Land use, land use change and forestry for 1990 – 2013 under UNFCCC, Kyoto Protocol and decision No. 529/2013/EU of the European Parliament*

| Sector | CRF Category/ Issue | Review Recommendation | Review Report/ Paragraph | LV Response (status of implementation) | Chapter/Section in the NIR |
|---|---|---|---|---|---|
| Cross-sectoral | General | Link asap to The Land Parcel Identification System (LPIS) agency and identify solutions for transfer of agricultural soil management information to LULUCF group. Because of LPIS data peculiarity annual data has to be provided from since records started. This information has to be geo-referenced, either provided as polygons or as exact information for NFI plots, or in a different manner national experts have to agree upon | LULUCF, KP-LULUCF third part review | Discussions about cooperation with The Land Parcel Identification System agency are started; data are transferred to LSFRI Silava and status of land use is compared with the NFI data. About 10 % difference is found between identification of cropland and grassland due to rapid changes in land management approaches, but detailed analyse is not yet done due to insufficient resources for georeferencing the NFI plots and sectors within plots. Detailed analysis is planned for 2016. | Will be implemented into next submissions. |
| Cross-sectoral | General | Add English headings in excel spreadsheets in order to ensure readability and proper external QAQC of calculations, whenever that is possible or required | LULUCF, KP-LULUCF third part review | EPIM tool is in development stage. Technical work and quality assurance continued in 2015 and will be completed in 2016. The delay is associated with implementation of the CRF Reporter tool. | Chapter 6 and Chapter 11 |
| LULUCF | 4.B Cropland, 4.C Grassland | Updated geo-referenced soil map, with focus on organic soil mapping and association to land use | LULUCF, KP-LULUCF third part review | Temporary results will be available in 2016 after completion of soil mapping project, all NFI plots on former and currently used cropland and grassland on organic soils will be visited until 2017, and final reporting will be done in 2017. | Chapter 6, Section 6.5.1, 6.6.1 |

| Sector | CRF Category/ Issue | Review Recommendation | Review Report/ Paragraph | LV Response (status of implementation) | Chapter/Section in the NIR |
|---|---|---|---|---|---|
| LULUCF | 4.B Cropland4.C Grassland | Updated drainage mapping for cropland and grassland. Because of high level of emissions associated to these lands, there is need for a split on 'actively managed' and 'abandoned' drainage systems areas. An adequate assumption is that all such lands were actively drained in 1990. In order to derive the current actively managed areas, using actual crop cultivation data reported by farmers in LPIS as a proxy may be an adequate economically solution (to be tested) | LULUCF, KP-LULUCF third part review | Estimation of area of drainage ditches on organic soils in cropland and grassland will starts in 2016 when soil mapping project will be completed and temporary results will be available. Discussions about cooperation with The Land Parcel Identification System agency are started however NFI will be kept as a main source of data for the inventory to maintain integrity of land use accounting. | Chapter 6, Section 6.5 and 6.6 |
| LULUCF | 4.A Forest land, 4.B Cropland, 4.C Grassland,4.D Wetland, 4.E Settlements | Development of data to ensure time series back to 1970. If major changes in land use have occurred over the period 1970-1990, e.g. major drainage and extension of arable croplands, conversions from forests, etc then development of this time series based on existing spatial information would respond adequately to reporting guidelines. Otherwise, simple /arithmetical extrapolation of post-1990 conversions rates and use of any actual data on conversions (e.g. from/to forests) back in time can provide picture. For guidance on extrapolation see Ch.5 of Vol.1 of 2006 IPCC Guidelines. | LULUCF, KP-LULUCF third part review | The work on this issue is ongoing. Development of data of area of forest land and deforested land, carbon stock changes in living biomass and dead wood as well as harvesting stock are done to ensure time series back to 1970. | Chapter 6, Section 6.2 |

| Sector | CRF Category/ Issue | Review Recommendation | Review Report/ Paragraph | LV Response (status of implementation) | Chapter/Section in the NIR |
|---|---|---|---|---|---|
| LULUCF | 4.A Forest land, 4.B Cropland, 4.C Grassland | -Development of capacity to estimate SOC change in mineral soils for both agricultural and forest soils. For forest data on decomposition may be needed, although Finland data may be appropriate (to be discussed with finish colleagues in the bilateral activities). An alternative to be studied is to check for the existence of more detailed historical data regarding for soil C or humus content (%) at soil science or agro-pedology institute. Such data should have metadata, including soil management and land use. It can be used to derive country specific 'C stock change factors........'. Another alternative is to wait for EU LUCAS to produce such factors. | LULUCF, KP-LULUCF third part review | Improvement (evaluation of carbon stock changes in croplands and grasslands) planned within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy". Field data collection and analyses are done, scientific publication is under preparation. After publishing the results will be implemented in the GHG calculations. It is proposed to implement Yasso model in forest land, cropland and grassland on dry mineral soils to obtain information on carbon stock changes in soil. Results of our research show that EU LUCAS data are not suitable for calculation of carbon stock changes in soils for preparation of GHG inventory or other reports related to Climate Convention or the Kyoto Protocol. | Chapter 6, Section 6.4, 6.5 and 6.6 |
| | 4.A Forest land | Develop age dependent BEFs for major forest types/species. This is crucial for GHG inventory and projections, e.g. for FMRL (both for CP2, CP3) insofar as a model would be used for that. Majority of empiric forest models work with commercial or stem volume and BEFs as main inputs. This is feasible as long as tree biomass equations are under development in the country, while volume of commercial wood (or any other wood volume based parameter) are available. BEFs for stand age can be derived both for | LULUCF, KP-LULUCF third part review | Country specific BEFs for coniferous and deciduous trees are implement, but development of more accurate and growing stock dependent coefficients and equations for biomass calculation is in final stage. | Chapter 6, Section 6.4 |

| Sector | CRF Category/ Issue | Review Recommendation | Review Report/ Paragraph | LV Response (status of implementation) | Chapter/Section in the NIR |
|---|---|---|---|---|---|
| | | standing stock between volume and total biomass, or for annual increment by arithmetic in successive NFIs measurements for all ages and species. | | | |

# PART 2: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

# 11 KP-LULUCF

In 2015 Latvia made an inventory submission under UNFCCC, but not under Kyoto Protocol because the CRF Reporter could not deliver CRF tables for Kyoto Protocol LULUCF activities without errors. Even if minor inconsistencies may still exist in the reporting tables the present report is the official inventory submission of Latvia for the year 2016 under the UNFCCC and for the years 2015 and 2016 under the Kyoto Protocol.

## *11.1 GENERAL INFORMATION*

### 11.1.1 Definition of forest and any other criteria

The applied forest definition for the reporting is harmonized with the definition used within the NFI. The same forest definition is used in relevant chapters of the LULUCF sector reporting. The selected parameters are presented in Table 11.1. Additional criteria defined by the Forest Law of Latvia[256] are width of rows of trees of artificial or natural origin – they should be at least 20 m wide to be accounted as a forest. The whole country is considered as one sub-division in the reporting.

**Table 11.1 Selected parameters defining forest in Latvia for the reporting**

| Parameter | Range in FAO definition | Value |
|---|---|---|
| **Minimum land area** | 0.05-1 ha | 0.1 ha |
| **Minimum crown cover** | 10-30 % | 20 % |
| **Minimum height** | 2-5 m | 5 m |

Forest roads, cleared tracts, fire-breaks, seed orchards and other forest infrastructure with permanently removed vegetation and/or fertile soil layer are excluded from forest and are accounted under settlements; respectively, building of the forest road or drainage system is accounted as deforestation. Forest definition for the 2[nd] commitment period is not changed since the 1st commitment period.

### 11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

Latvia reported Forest management in the 1[st] commitment period and all lands reported under forest management in the 1st commitment are included in the Forest management accounting in 2nd commitment period, except deforested lands reported under activities of Article 3, paragraph 3, of the Kyoto Protocol. All afforested and deforested lands reported in the 1[st] commitment periods are represented in the 2[nd] commitment period as afforestation, deforestation or forest management. The latest category consists of naturally afforested lands, which are reported as land converted to forest land under the UNFCCC and forest management under the KP reporting. Afforested lands, where natural forest regeneration methods are applied, active forest management takes place and forest owner completed

[256] *Latvijas Republikas Saeima, "Meža likums, 2000. (Forest law)", published in 24.02.2000.*

legal procedure of the land use change, are reported under the Afforestation activities. Activity data for this category is delivered by the State forest service (stand wise forest register) and National forest inventory (land use history).

Latvia reports mandatory land activities of ARDFM. It elected to report forest management under the KP 3.4 activities for the 2nd commitment period.

### 11.1.3 Application of natural disturbance provision on Article 3.3 activities and Forest Management

Latvia is not reporting natural disturbances; therefore, accounting of lands reported under natural disturbances is not necessary, neither for AR nor for FM.

### 11.1.4 Description of how the definitions of each activity under Article 3.3 and each mandatory and elected activity under Article 3.4 have been implemented and applied consistently over time

On the basis of the definitions provided in the Decision 19/CMP.136, afforestation and reforestation that take place on agricultural land have to be included in the Article 3.3: a common forest management approach in Latvia is exploitation of natural re-growth by seeds of adjacent trees in forest regeneration and afforestation. In addition these transitions are essentially due to political decisions under the EEC Regulations 2080/92 and 1257/99 (art.10.1 and 31.1). However, only planted trees and managed forest stands, where natural regeneration is applied as the afforestation method, are reported under afforestation. The information is provided by the NFI and State forest service. The rest of afforested lands are reported under forest management in the KP reporting.

Concerning deforestation activities, as mentioned above, in Latvia land use changes from forest to other land use categories are allowed in very limited circumstances; however, due to large share of forest lands the most of economic activities associated with building of new infrastructure takes place on forest lands. The most common type of land use change in this reporting is construction of forest roads which is not considered as land use change according to national legislation but from the point of view of emissions it is land use change. Conversion to agricultural land occurs to less extent and generally is associated with removal of woody vegetation from abandoned farmlands and it was more common in 1990s.

Latvia does not apply carbon equivalent forest conversion (CEFC).

### 11.1.5 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified

Under Article 3.4 activities Latvia reports only forest management; respectively, there is no need to build up a hierarchy between forest management and other Article 3.4 activities (i.e. forest has anyway higher hierarchical position in classification of activities on land).

## *11.2 LAND-RELATED INFORMATION*

### 11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

Latvia implements spatial explicit approach (Reporting approach 3 according to the 2006 IPCC Guidelines Chapter 3.3.1 and Reporting method 1 according to 2013 KP supplement) in reporting of lands subject to Article 3.3. and Article 3.4 activities. The approach is consistent with calculations of land use changes under the LULUCF sector reporting. The spatial assessment units for the submission of the Kyoto Protocol and LULUCF sector report cover the entire territory of Latvia. Latvia is mapping land use to 0.1 ha for afforestation, reforestation and deforestation.

### 11.2.2 Methodology used to develop the land transition matrix

The land use matrix is based on the results of land use changes to forest derived from the NFI of the period 2004-2008 and 2009-2013 and 2010-2014. Methodology for estimation of earlier land use changes, including deforestation activities is under development in the LSFRI Silava as a part of National Forest inventory (NFI). The assessment methods at the NFI grid points are described above. Estimation of afforested and deforested area in 2014 is based on extrapolation of the NFI data and the research results.

Historical figures of deforestation were estimated using remote sensing methods. LANDSAT satellite image series from 1990, 1995 and 2000 were geographically referenced to fit to the actual location of sample plots before satellite image analysis and non-guided classification of vegetation types was done using ERDAS Imagine software.

Cumulative information on area accounted under forest management, deforestation, afforestation and reforestation is provided in Table 11.2.

**Table 11.2 Summary of area under forest management, afforestation & reforestation and deforestation accounting (kha)**

| [7. KP LULUCF][NIR-2] | Remaining afforestation and reforestation | Remaining deforestation | Remaining forest management |
|---|---|---|---|
| 1990 | 0.23 | 2.5 | 3123.99 |
| 1991 | 0.96 | 5 | 3127.6 |
| 1992 | 2.91 | 7.5 | 3132.38 |
| 1993 | 5.29 | 10 | 3138.2 |
| 1994 | 6.83 | 12.5 | 3142.85 |
| 1995 | 8.79 | 14.99 | 3151.47 |
| 1996 | 11.33 | 16.26 | 3162.06 |
| 1997 | 13.74 | 17.52 | 3171.5 |
| 1998 | 15.25 | 18.78 | 3182.7 |
| 1999 | 15.93 | 20.04 | 3193.26 |
| 2000 | 17.53 | 21.3 | 3204.6 |
| 2001 | 18.92 | 22.88 | 3217.74 |
| 2002 | 19.57 | 24.46 | 3229.16 |
| 2003 | 21.57 | 26.04 | 3236.33 |
| 2004 | 23.06 | 27.62 | 3247.89 |
| 2005 | 24.66 | 29.19 | 3257.19 |
| 2006 | 26.52 | 30.77 | 3263.13 |

| [7. KP LULUCF][NIR-2] | Remaining afforestation and reforestation | Remaining deforestation | Remaining forest management |
|---|---|---|---|
| 2007 | 27.4 | 32.35 | 3269.86 |
| 2008 | 32.36 | 33.93 | 3274.7 |
| 2009 | 34.58 | 36.23 | 3271.21 |
| 2010 | 37.38 | 38.52 | 3267.12 |
| 2011 | 39.98 | 40.82 | 3263.24 |
| 2012 | 40.94 | 43.12 | 3261 |
| 2013 | 40.94 | 45.41 | 3259.72 |
| 2014 | 40.94 | 50.57 | 3258.44 |

### 11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

Since the geographical location of NFI sample plots is known, the results can be computed for geographically referenced areas. Geographical locations are identified by the coordinates of centres of the NFI sample plots.

The methodology for reporting is based on the NFI which uses a permanently below ground marked 4 x 4 km grid across all of Latvia with four permanent sample plots of 500 $m^2$ size at each grid point. Sample plots are split into up to 10 sectors if different land use categories or vegetation type in the same category are presented in a single plot. In total, 23583 sectors in 16383 sample plots (Figure 11.1) were used for calculations of land use and carbon stock changes in living and dead biomass. Number of sectors may change from cycle to cycle, because of land use changes. Borders of sample plots are constant all the time. Each sector in average represents about 400 ha of the country area including internal water bodies. ARD activities are accounted as long as the forest definition is met (minimum assessment unit 0.1 ha), except AR in extensively managed grassland and cropland, if the trees do not reach at least 2 m height, because growth of trees in such areas usually do not mean afforestation, but delayed grass cutting, as well as AR, if human induced afforestation cannot be approved (the main criteria are planting of trees or other early management activities targeted on increase of growing potential of the forest stand, afforestation is also considered in areas, where legal procedure of land use change is completed). The sizes of the sub-areas with different land use at the permanent sample plots need to be larger than 1/10 (> 30 $m^2$) of the total sample plot area to be assessed. If this precondition is met the polygon that divides the different areas of land uses within the sub-plot is measured using polar-coordinates. At a site, sketches are drawn and the polygon data are entered into the geographic information system of the portable input device. If the former border line can be recognized in the follow-up NFI cycle, it is kept.

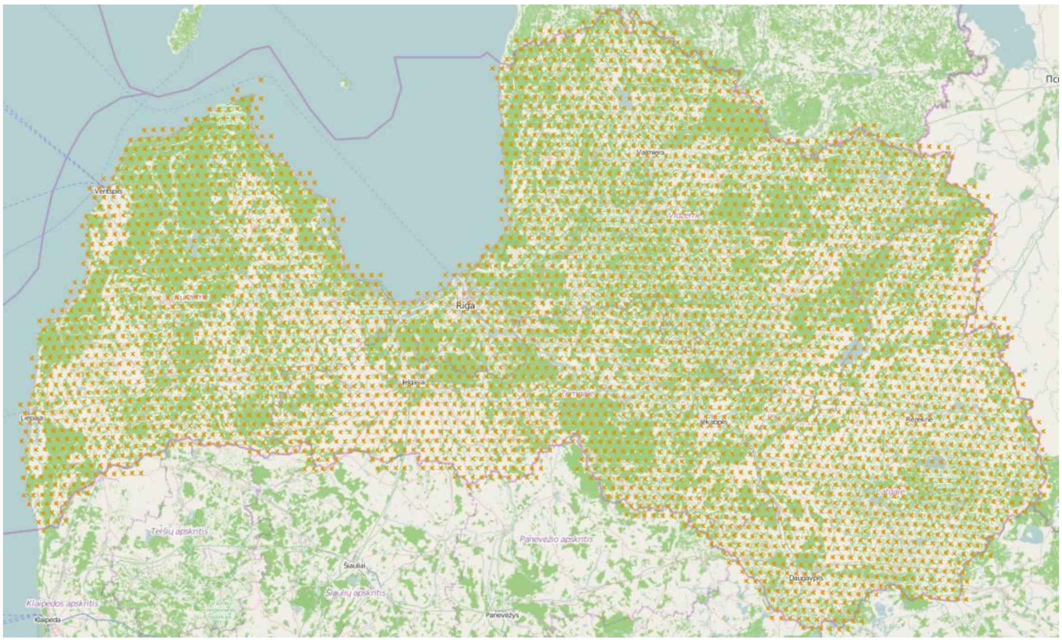


**Figure 11.1 Permanent grid of the forest inventory plots**

During the 2nd NFI cycle the fact of afforestation and deforestation is fixed mathematically by accounting area of sectors, where land use category is changed from one type to another and multiplying by area (in ha) represented by 1 $m^2$ of sample plots. Uncertainty is determined as error of proportion. The method is not fully implemented and in many cases land use changes should be determined manually (when 2 or more sectors representing different land uses are merged into new sector). GIS tools will be used in further inventories to process land use information as well as information on destiny of every single tree – if it is cut due to deforestation or just accounted under another land use category. So the calculation will be done in 2 levels – land use and destiny of trees.

Changes in forest area were detected on the basis of the NFI data. The following afforestation/reforestation activities that occurred or could have occurred on or after 1990 are included in the reporting of these activities:

- planted or seeded grassland;
- abandoned grassland which are afforested and converted to forest lands.

In Latvia all land use categories (cropland, grassland, forest, settlements and wetlands) are considered managed; therefore any land use change occurs between in lands and, consequently, is direct human-induced.

Afforested/reforested areas are to be considered legally bound by national legislation. Usually these activities have resulted from a decision to change the land use by planting or seeding or managing of afforested lands.

## *11.3 ACTIVITY-SPECIFIC INFORMATION*

### 11.3.1 Methods for carbon stock change and GHG emission and removal estimates

The National Forest Inventory (NFI) of Latvia is the main data provider for the GHG reporting in LULUCF sector and Kyoto protocol Article 3, paragraph 3 and Article 3, paragraph 4 activities.

Soil properties (carbon stock in litter and mineral soil) in forest lands was determined in permanent 16 x 16 km grid of 95 sample plots of the 1$^{st}$ level forest monitoring programme (Figure 11.2). The results of forest soil monitoring demonstrate that mineral soils in forest lands are not a source of emissions, but can be a net sink. However, number of plots is insufficient to finalize conclusions about carbon stock change in forest lands. The increase of number of plots to 210 is proposed in the Forest monitoring programme providing more accurate data on soil carbon stock changes in forest lands. No soil carbon stock changes are considered in afforested lands, according to research data demonstrating insignificant carbon stock differences in forest land and grassland.

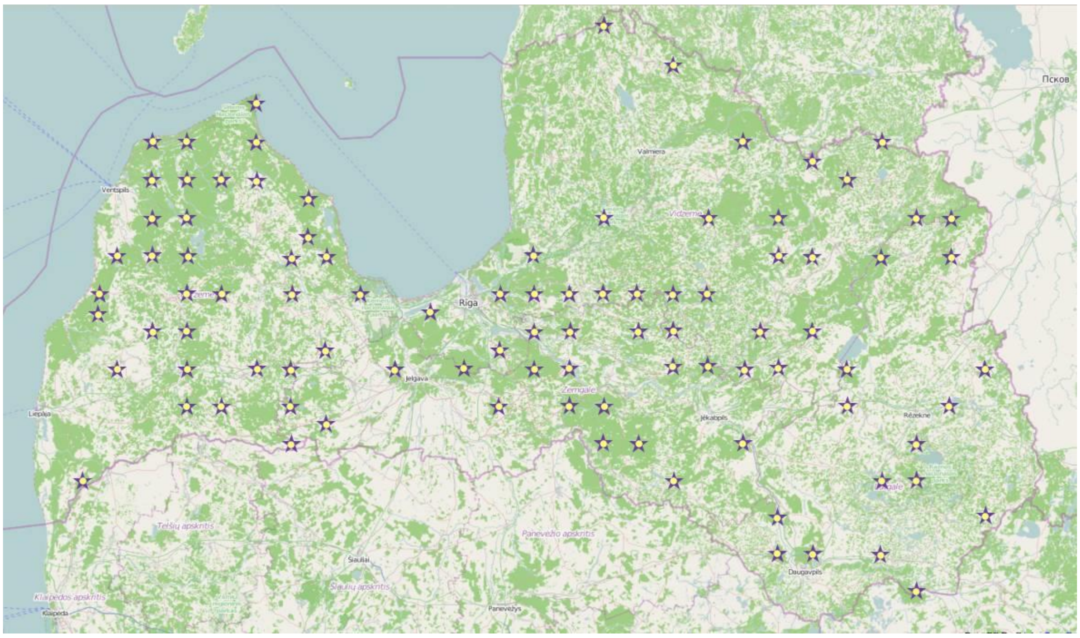


**Figure 11.2 Permanent grid of the Level 1 forest monitoring plots**

#### 11.3.1.1 Description of the methodologies and the underlying assumptions used

Methods for estimating carbon stock changes in forests (for Article 3.3 afforestation, reforestation, deforestation and Article 3.4 forest management) are the same as those used for the LULUCF inventory reported under the UNFCCC. Estimations of carbon stock changes in living biomass on forest land remaining forest in the 1st cycle of the NFI are based on measurements of radial increment of growing trees and calculation of actual potential increment of timber volume of all living trees; in the second period, increment is calculated as stock difference of living trees; mortality is accounted as the stock of trees changing status (destiny) from living trees to dead and left in the stand; harvesting stock is accounted as stock of trees changing status (destiny) to dead and extracted. The NFI data are harmonized with the State forest service data provided information by application of linear factor (+26 %) to the whole accounting period, because the basics of the methodology used for calculation of harvesting stock in SFS is not changed for several decades.

The destiny of trees or change of status of tree is classified as follows:

- Living trees:
    - Still growing (trees remaining alive since the previous NFI cycle),
    - Ingrowth (new trees appearing in the NFI plot, measured first time),
- Commercial harvesting:
    - Harvested and extracted (living trees in previous NFI cycle, removed from the plot between previous and current measurement),
    - Diseased and extracted (mostly dead standing or laying trees in previous NFI cycle, removed from the plot between previous and current measurement),
- Mortality:
    - Harvested and left (living trees in previous NFI cycle, cut but left in the plot between previous and current measurement, mostly undergrowth trees),
    - Diseased (dry) and left (living trees in previous NFI cycle),
    - Thrown out (by wind) and left (living trees in previous NFI cycle, uprooted by wind),
    - Broken, dead (living trees in previous NFI cycle),
    - Eaten by beavers (living trees in previous NFI cycle, specific and common type of damages),
    - Broken top, living tree (such trees are accounted as 2 pieces – as living tree and dead wood).

There are 3 categories of dead trees, including dead standing trees, which might change their destiny to dead laying trees or rotten parts of trees. This conversion is excluded from mortality accounting.

Since research data are available, historical figures on mortality are recalculated and provided in the inventory considering 20 years decay period for dead biomass, respectively; calculations are done for the period 1970-2013. Removals of $CO_2$ in living biomass on afforested areas are calculated on the base of weighted average of timber stock changes in 1-25 years old forest stands on non-forest lands.

The difference between the SFS and NFI is not due to illegal felling. The permissions for timber extraction are given for area and the area of final felling is the same in NFI and SFS reports. There is considerably higher growing stock reported under the NFI and, respectively, extracted volumes. Additional timber, which does not appear in statistics of production of sawn products, is generally used as firewood in households and other small scale applications. The findings of NFI on additional harvested volumes fully comply with energy sector statistics considered overestimated in utilization of solid biofuel.

No harvesting takes place in lands converted to forests; therefore no artificial emissions in living biomass are reported in this category. However if by some reasons (for instance, thinning) harvesting took place on afforested area it is also reported in national statistics and is included in Forest management related carbon stock changes. Therefore there is no risk of underestimation of emissions from living biomass.

Losses in living and dead biomass due to deforestation are reported based on average growing stock in forest land. The method as well as the values used in calculations is explained in details in previous sections. All biomass, including stem, branches and below-ground biomass is considered instantly oxidized.

Carbon stock changes in dead wood, litter and soils are reported under deforestation assuming that average carbon stock on forest lands remaining forest in dead biomass pools is instantly oxidizing during conversion, but carbon soil in mineral soils stabilizes in 20 years. For conversion to settlements it is assumed that 20 % of carbon in 0-30 cm deep soil layer turns into emissions in 20 years. The methods are described in previous sections under Croplands and Settlements categories.

The most important changes due to implementation of the 2006 IPCC Guidelines and IPCC Wetlands Supplement are changes in emission factors for $CO_2$, $N_2O$ and $CH_4$ for drained organic soils, updates in calculation of harvested wood products and carbon losses in soil due to disturbances caused by land use conversion from forest land to settlements and cropland.

#### 11.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected and mandatory activities under Article 3.4

According to the NFI conversions to forestland that can be classified as afforestation/reforestation take place only on grasslands. The soil monitoring study initiated in 2012 by the Joint stock company "Latvia state forests" and Ministry of Agriculture demonstrates no statistically significant difference in carbon stock in mineral soil in grassland, forest land remaining forest in fertile stand types and in afforested lands, i.e. no changes appear in soil organic matter (SOM) due to afforestation. The results are based on 95 plots in forest, 34 plots in afforested lands and 40 plots in grassland; for each plot 4 repetitions have been taken.

It is assumed in calculation of carbon stock changes in afforested lands, that dead wood and litter will reach values characteristic for the forest lands (average figures of the 1$^{st}$ cycle of the NFI and 2$^{nd}$ round of forest soil monitoring, representing the same time period) in 150 years, which is twice average rotation of the most common tree species in afforested lands (birch and spruce). The rationale behind selection of 150 long transition period is decomposition of dead wood, which reach equality with forest lands at the end of the second rotation; however, this expert judgement will be evaluated in future using field measurement data.

Data from the BioSoil net (95 plots) have been elaborated for the years 2006 and 2012 putting together the mineral soil and litter pools and then analyzing the trend in changes of the total carbon stock and its significance. The result shows that there is no statistically significant difference in total carbon stock between 2006 and 2012, respectively no carbon stock changes in these pools can be reported. This represents a quantitative demonstration that soil is neither sink nor a source of $CO_2$ on short term.

The litter and soil pools have been analyzed altogether since the separation of humic layers in the year 2006 and in the year 2012 have not been done following the same methodology, so that data on litter and data on soil cannot be compared among those 2 years. However, the accumulation of litter is always associated with increase of humic layer, and, vice versa, a decrease or a removal of litter causes a decrease of humic layers and therefore of soil carbon stocks in the soil carbon pool, as defined in the 2006 IPCC Guidelines. Consequently, whether the litter stock increases also the soil stock increases and vice versa, to a decrease in litter stock a decrease in soil stocks (humic layers) follows. Therefore, the analysis conducted on the sum of both pools giving information on the total trends gives also the needed information on the trend of both pools i.e. if the sum of litter and soil is not a source then both, the litter and the soil are not a source.

Emissions from natural and controlled biomass burning due to are estimated according to methodology described in section Biomass Burning.

#### 11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

It is recognized that:

- for Article 3, paragraph 4 activities, the issue of "factoring out" was solved during negotiations with the cap for Forest Management and with the net-net accounting for the other Article 3, paragraph 4 activities;
- for Article 3, paragraph 3 activities, the dynamic effect of age is not relevant since all these activities have occurred after 1990;
- for the elevated $CO_2$ concentration and the indirect nitrogen deposition, there are no methodologies adopted by the UNFCCC.

$N_2O$ emissions associated with conversion to cropland are reported using the methodology provided in the 2006 IPCC Guidelines and IPCC Wetlands Supplement, for organic soil. Carbon stock changes for calculation of the emission factor are taken from losses of soil organic carbon stock due to conversion for mineral soils and constant emissions factor (7.9 tonnes C $ha^{-1}$) is used for organic soils[257]. Also for grasslands and wetlands (accounted as rewetted non-forest lands) the default emission factors are used, respectively 6.1 and 0.5 tonnes C $ha^{-1}$.

#### 11.3.1.4 Changes in data and methods since the previous submission (recalculations)

Implementation of changes due to use of 2006 IPCC Guidelines and IPCC Wetlands Supplement for certain categories and implementation of the 2nd cycle and floating cycle of the NFI for 2014 continued this year, particularly area of forest land is recalculated due to review of land use categories in the NFI plots.

[257] *According to 2013 SUPPLEMENT, TABLE 2.1 TIER 1 CO2 EMISSION/REMOVAL FACTORS FOR DRAINED ORGANIC SOILS IN ALL LAND-USE CATEGORIES (Cropland, drained, boreal and temperate).*

Methodological consistency between the reference level and reporting for forest management during the 2nd commitment period, including the area accounted for the treatment of harvested wood products is secured by implementation of the same methodological approaches for the whole accounting period and recalculation of the whole time series according to a new methodology. A technical correction to FMRL would be recalculated because of reasons highlighted above, in a consistent way.

It is planned to implement country specific method for estimation of FMRL and recalculation of historical data affecting the FMRL, This issue is under consideration currently, while new data is coming out from NFI and other sources.

#### 11.3.1.5 Uncertainty estimates

Uncertainty estimates are described under corresponding LULUCF chapters of NIR.

#### 11.3.1.6 Information on other methodological issues

The methodology used for reporting under the Kyoto Protocol is described in detail in previous sections.

#### 11.3.1.7 The year of the onset of an activity, if after 2013

The starting year of the activities reported can directly be derived from the land-use change matrix (Table 6.9). The activities in the 2nd commitment period are reported starting with 2013.

## 11.4 ARTICLE 3.3

### 11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

Changes in forest area were detected on the basis of the NFI data. The following afforestation/reforestation activities that occurred or could have occurred on or after 1990 are included in the reporting of these activities:

- trees planted or sown on grassland or abandoned cropland;
- afforested lands where management activities (tending, thinning, soil scarification) are identified by the NFI teams;
- grassland, where natural regeneration methods are used to proceed afforestation and human induced forest management is approved by official land use transformation in land use register.

### 11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

In Latvia temporarily unstocked areas (e.g. harvested area) remain forests and are not accounted as deforestation if no other activities prohibiting forest regeneration are implemented. The NFI teams are trained to distinguish between forest management and land use changes. The legal requirements for the forest regeneration are to reach certain dimensions and density of trees within 5-10 years, depending on forest site type. Normally these requirements will not be reached only in case of flooding or human induced prohibiting of forest regeneration, like building of asphalted road. In such cases conversion to non-forest land can be easily identified. In all other cases it is decided to use the same approach as for conversion from cropland to grassland and backward – if land use change is approved within 2 NFI cycles, the land use change is recorded. Identification of transition in such cases takes 10 years, which complies with the legally permitted forest regeneration period for the most of forest stand types. Afforested areas fulfil the criteria for the forest definition used in the Latvia's NFI, which besides other threshold values is minimum width of 20 m.

Deforested areas can be detected by two combined characteristics:

- the forest definition of Latvia's NFI does not apply (as described above within 2 NFI cycles, the identification of conversion takes 10 years);
- there are significant visible changes in soil structure or ground vegetation which do not complies with the natural succession of a forest (consequences of anthropogenic activities like ploughing, crop production, mowing or construction activities or natural abortion of the forest and its stand by e.g. landslides, the identification of conversion takes 5 years).

Deforestation includes artificial measures prohibiting regeneration of unstocked forest lands. In any natural conditions forests can regenerate, except, for instance, flooding or formation of dunes.

Deforestation and relevant land use changes (construction of forest roads) are regulated by national laws.

Restocking is assumed for forest areas that have lost forest cover through harvesting or forest disturbance, unless there is deforestation as described above.

### 11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

Information on the size and location of forest areas that have permanently lost forest cover (due to a tillage or construction) is collected on 5 years period basis by the NFI. These data can be validated by national statistics; however, no historical records since 1990 are available for statistics and only recent data can be used for the validation.

### 11.4.4 Information related to the natural disturbances provision under Article 3.3

Latvia is decided not to report natural disturbances, because trees diseased due to natural disturbances are usually extracted in salvage logging (sanitary clear-felling or thinning); therefore, accounting of lands reported under natural disturbances is not necessary or even possible due to salvage logging, neither for AR nor for FM.

### 11.4.5 Information on Harvested Wood Products under Article 3.3

The emissions from the harvested wood products pool that have been accounted during the 1$^{st}$ commitment period were not accounted on the basis of instantaneous oxidation;

respectively, they should not be excluded from the accounting for the 2nd commitment period.

Harvested wood products resulting from deforestation have been accounted on the basis of instantaneous oxidation using proportion approach; respectively, if the projected felling stock in deforested areas is 1 % of the total felling stock, the proportion of harvested wood products to which the instant oxidation approach is applied is 1 %.

The carbon dioxide emissions from harvested wood products in solid waste disposal sites are not accounted, and the carbon dioxide emissions from wood harvested for energy purposes have been accounted on the basis of instantaneous oxidation under carbon losses from living biomass.

## *11.5 ARTICLE 3.4*

### 11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

The area of forest land reported for Afforestation/Reforestation and Deforestation under the Kyoto Protocol is not equal to the area reported for Land use changes from and to forests in the UNFCCC greenhouse gas inventory, because lands afforested / deforested in 1990-1993 already completed 20 years transition period and under the UNFCCC greenhouse gas inventory they are accounted under land use categories retaining their land use status, respectively, lands afforested in 1990-1993 are reported in 2010-2014 under the forest land remaining forest land category. In the Kyoto protocol reporting transition period is not considered; therefore, afforested lands will always be afforested lands, except the case if they are deforested in future. The total area of forest lands, however, is the same in the both reports. All land use changes from and to forests take place on managed lands and therefore are considered to be human induced.

All forests are considered as managed land. Forest management activity is practised on the forest area as defined above.

The Forest law lays down provisions on management and utilisation of forest. Afforested lands are also considered as subjects of forest law apart from reason of afforestation. Therefore all afforested lands are also considered managed.

### 11.5.2 Information relating to Forest Management

According to the Forest law[258] forest management in Latvia is sustainable utilization and management of forests and forest resources to preserve biodiversity, productivity and vitality of forests as well as ability to regenerate, while providing economic, social and cultural opportunities for the benefit of present and future generations. Consequently, all forests, as well as all forest lands according to national definitions are considered as managed land. Forest management activity is practiced on the forest area (forest stands) as defined above. The area of forest land and the area under forest management (forest land remaining forest) in the end of 2014 decreased in comparison to 1989 because of

[258] *Latvijas Republikas Saeima, "Meža likums, 2000."*

deforestation; however, total area reported under forest management is increasing due to reporting of naturally lands, where no commercial activities takes place, under forest management.

The Forest law lays down provisions on management and utilization of forest. Afforested lands are also considered as subjects of forest law apart from reason of afforestation. Therefore all afforested lands are also considered managed. The purpose of the Law is to promote economically, ecologically and socially sustainable management and utilization of the forests in such a way that forests provide a sustainable satisfactory yield while biological diversity is being maintained.

#### 11.5.2.1 Conversion of natural forest to planted forest

No emissions arising from the conversion of natural forests to planted forests are accounted for, because no such kind of activities takes place in Latvia in accordance with any supplementary methodological guidance developed by the IPCC.

#### 11.5.2.2 Forest Management Reference Level (FMRL)

Latvia's forest management reference level is -16.302 Mt $CO_2$ eq. and -14.255 Mt $CO_2$ eq. (including harvested wood products) as inscribed in the appendix to the annex to decision 2/CMP.7. Latvia will make technical corrections for the forest management reference level according the requirements of decision 2/CMP.7 and 2/CMP.8.

#### 11.5.2.3 Technical Corrections of FMRL

The need for Technical Correction is determined by following reasons:

- The method used for GHG reporting changed after the adoption of FMRL as part of improving inventory quality and due to conversion of calculations from the IPCC GPG LULUCF 2003 to 2006 IPCC Guidelines and IPCC Wetlands Supplement. For instance, emission factors for organic soil ($CO_2$ and $N_2O$) are changed. Emission factors for biomass burning are also changed due to implement of the new guidelines. The inconsistency in calculation of the dead wood stock is found in the previous inventory report during the quality assurance procedures, leading to considerable overestimation of carbon stock changes in dead wood due to deforestation and afforestation, as well as biomass burning. These changes lead to a recalculated time series that also lead to an inconsistency between FMRL and reporting of FM in the second commitment period;
- New non-$CO_2$ GHG sources are included in reporting for FM in the second commitment period. For instance, calculation of $CH_4$ emissions from drained organic soils, drainage systems and rewetted soils are introduced in the current inventory;
- Recalculated historical data was done for the most important parameters, like increment of living biomass, mortality and commercial felling due to availability of data from the NFI 2$^{nd}$ cycle. Commercial felling stock was increased by 26 %, mortality – by 21 %, increment of living biomass was reduced by 0.1 %. The NFI data are compiled once in a 5 year period. Since the data on land use changes from the 2$^{nd}$ NFI cycle is available in this inventory, deforested area for the last 5 years period, as

well as distribution of drained and rewetted soils is recalculated and Technical Correction is necessary to include new information in the FMRL;

- The accounting of HWP has been also improved since estimation of the FMRL which was submitted before Decision 2/CMP.7 and Technical Correction related to HWP are also necessary.

In 2014 the Technical Correction of Latvia`s FMRL was calculated by European Commission's Joint Research Centre (JRC) and constituted 9.922 Mt $CO_2$ eq.

Technical Correction is done on the basis of the FMRL considering instantaneous oxidation for HWP. Tehnical Correction was calculated based on a model re-calibration. A full re-run of the model will be carried in the future to allow Latvia to implement a complete Technical Correction.

#### 11.5.2.4 Information related to the natural disturbances provision under Article 3.4

Latvia does not intend to apply the Natural Disturbance provision, respectively, annual emissions resulting from natural disturbances and the subsequent removals during the commitment period in those areas are not estimated and not excluded from the accounting for forest management under Article 3, paragraph 4, of the Kyoto Protocol during the second commitment period.

#### 11.5.2.5 Information on Harvested Wood Products under Article 3.4

Current forest management reference level (FMRL) is based on a projection; the emissions from harvested wood products originating from forests prior to the start of the second commitment period have been included in the accounting.

The emissions and removals resulting from changes in the harvested wood products pool do not include imported harvested wood products, irrespective of their origin. FAOSTAT data are used to identify share of imported harvested wood products. Calculations are done according to IPCC KP Supplement and scientifically verified methodology[259].

Emissions from harvested wood products originating from forests prior to the start of the 2nd commitment period have been calculated in the reference level in accordance with decision 2/CMP.7, annex, paragraph 16. The methodology for calculation of harvested wood products is based on IPCC KP Supplement[260] and earlier studies on the forest management reference level[261]. Half-lives are based on table 3a.1.3 of the IPCC GPG LULUCF 2003 of two years for paper, 25 years for wood panels and 35 years for sawn wood. Instant oxidation is considered for biomass originated in deforested areas.

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[259] *T. Hiraishi et al., eds., "Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol" (IPCC, Switzerland, 2013), http://www.ipcc-nggip.iges.or.jp/public/kpsg/pdf/KP_Supplement_Entire_Report.pdf; Andis Lazdiņš and Līga Strūve, "Contribution of Harvested Wood Products to Greenhouse Gas Emissions due to Forest Management in Latvia," in Mežzinātne. Special Issue. Abstracts for International Conferences Organized by LSFRI Silava in Cooperation with SNS and IUFRO, vol. 25 (58) (presented at the OSCAR 2012, Riga: LSFRI Silava, 2012), 79–82; Sebastian Rüter, Projection of Net-Emissions from Harvested Wood Products in European Countries (Hamburg, 2011), Hamburg.*

[260] *T. Hiraishi et al., eds., "Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol" (IPCC, Switzerland, 2013), http://www.ipcc-nggip.iges.or.jp/public/kpsg/pdf/KP_Supplement_Entire_Report.pdf.*

[261] *Sebastian Rüter, Projection of Net-Emissions from Harvested Wood Products in European Countries (Hamburg, 2011), Hamburg; Andis Lazdiņš and Līga Strūve, "Contribution of Harvested Wood Products to Greenhouse Gas Emissions due to Forest Management in Latvia," in Mežzinātne. Special Issue. Abstracts for International Conferences Organized by LSFRI Silava in Cooperation with SNS and IUFRO, vol. 25 (58) (presented at the OSCAR 2012, Riga: LSFRI Silava, 2012), 79–82.*

Activity data for the harvested wood products categories used for estimating the harvested wood products pool removed from domestic forests, for domestic consumption and for export are obtained in FAOSTAT and verified by internal research data and expert judgements.

Half-lives used in estimation of the emissions and removals for these categories are in accordance with decision 2/CMP.7, annex; respectively 2 years for pulp-wood, 15 years for plate-wood and 25 years for sawn-wood.

### 11.5.3 Information relating to Cropland Management, Grazing Land Management, Revegetation and Wetland Drainage and Rewetting if elected, for the base year

Not relevant.

## *11.6 OTHER INFORMATION*

### 11.6.1 Key category analysis for Article 3.3 activities, forest management and any elected activities under Article 3.4

In 2014, net annual emissions from forest management, afforestation, reforestation and deforestation activities were 886.78 kilotons of $CO_2$ eq. This value is the total of all emissions and removals from activities under Article 3.3 (Figure 11.3 and Figure 11.4) and forest management activity under Article 3.4 of the Kyoto Protocol and includes: removals from the growth of forest and emissions from the conversion of land to forest after 1989; emissions from harvesting of forest remaining forest since 1990; emissions and removals from harvested wood products from forest land; emissions from deforestation; emissions from biomass burning due to natural forest fires and incineration of harvesting residues, mineralization of soil nitrogen associated with afforestation or deforestation since 1990 and management of organic soils in forest land, afforested or reforested land and deforested land.

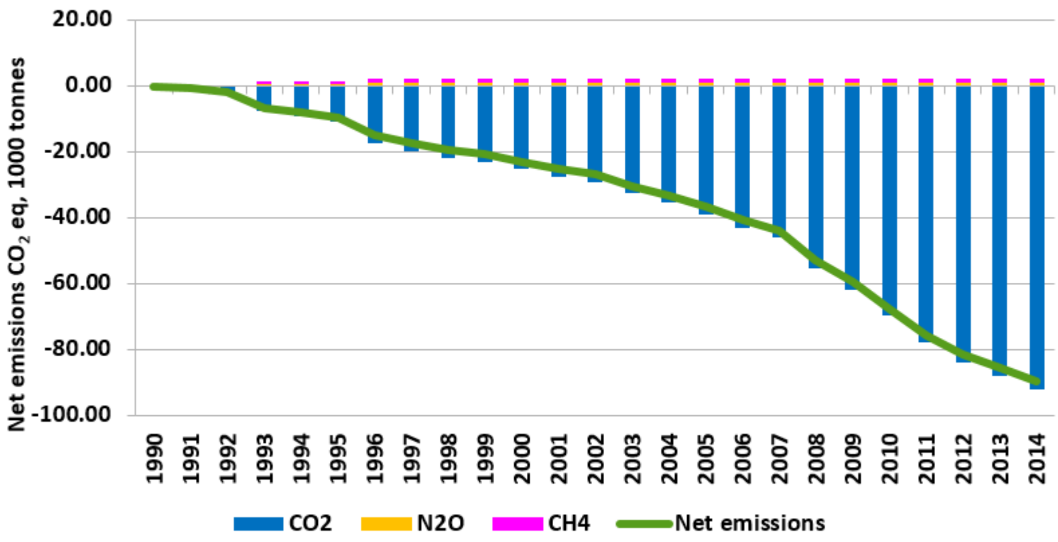


**Figure 11.3 GHG emissions due to afforestation**

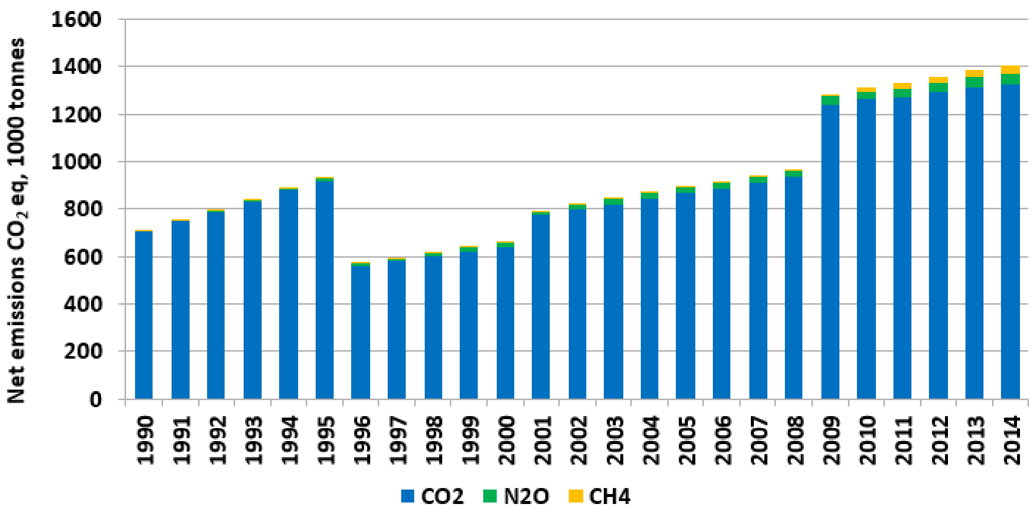


**Figure 11.4 GHG emissions due to deforestation**

Removals of $CO_2$ in living biomass is the most significant driver to have negative balance of the net GHG emissions during the reporting period; however, with reduction of $CO_2$ removals the role of other GHGs increases, particularly, $N_2O$ emissions from organic soil is a key source of emissions (Figure 11.5).

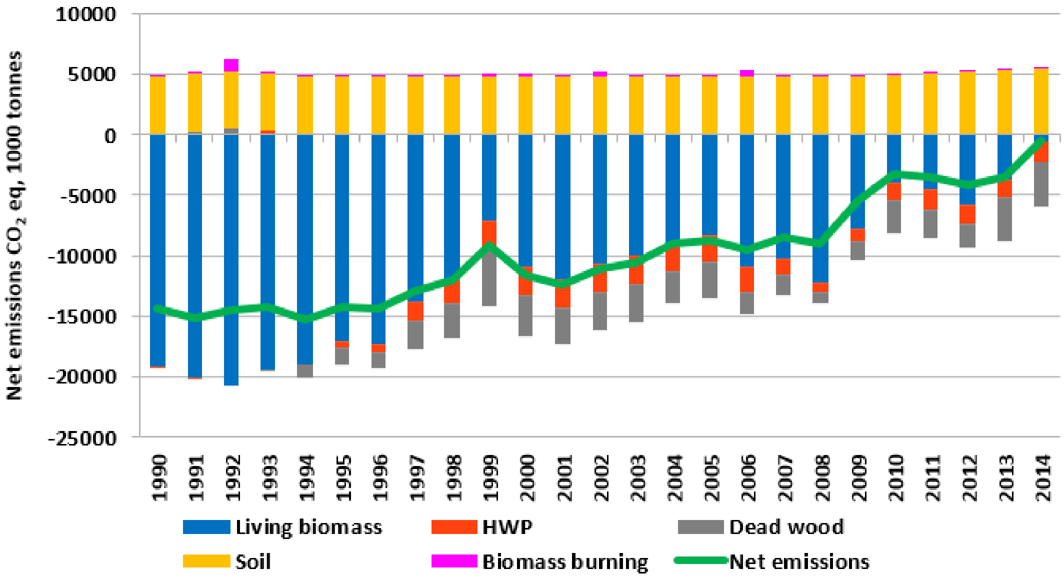


**Figure 11.5 GHG emissions due to forest management**

## *11.7 INFORMATION RELATING TO ARTICLE 6*

There are no lands subject to Article 3.3 and Article 3.4 activities which are also subject to projects under Article 6.

# 12 INFORMATION ON ACCOUNTING OF KYOTO UNITS

## 12.1 Background information

Chapter 12 and 14 include information on the Latvia's emission trading registry. The accounting on Kyoto units and the public available information is described in chapter 12. Any significant changes in the national registry are reported in chapter 14.

The standard electronic format tables are included in the submission (see "RREG1_LV_2015.xlsx" attached to the submission). The SEF tables include information on the AAU, ERU, CER, t-CER, l-CER and RMU in the Latvia's registry on 31.12.2015 as well as information on transfers of the units in 2015 to and from other Parties of the Kyoto Protocol.

## 12.2 Summary of information reported in the SEF tables

According to decision 15/CMP.1, annex, part 1, section E each Party must include information on its aggregate holdings and transactions of Kyoto units in its annual report. The information has to be reported in the Standard Electronic Format (SEF), which is an agreed format, embodied in a special report, for reporting on Kyoto units.

The SEF for 2015 was generated on 7 January 2016 with the Union registry in version 6.7.3, provided by the EU commission on 03.08.2015 and the SEF application version 3.6.1, provided by the secretariat at 23.11.2015.

At the beginning of the 2015 there were 66 332 433 AAUs, 418 607 ERUs, 322 904 CERs in the Party holding accounts and 5 317 ERUs, 21 550 CERs were held in entity holding accounts. At the beginning of 2015 10 499 146 EUAs, 848 191 CERs and 49 013 ERUs were stored in Retirement account.

At the end of 2015 28 249 726 AAUs were left in National holding accounts and 21 550 CERs and 5 317 ERUs were held in the entity holding accounts.

48 478 397 EUAs_AAUs, 490 531 ERUs, 6 233 333 RMUs and 1 251 640 CERs were left in Latvia's national retirement account during compliance period at the beginning of 2015 and therefore these allowances are also stored in Retirement account.

The registry did not contain any RMUs, t-CERs or l-CERs and no units were in the Article

3.3/3.4 net source cancellation accounts and the t-CER and l-CER replacement accounts.

Total of Kyoto protocol units 76 728 123 AAUs, 495 848 ERUs, 12 457 753 RMUs and 1 273 190 CERs were stored in the ETR accounts at the end of 2015.

Latvia's CP1 assigned amount is 119 182 130 tonnes $CO_2$ eq.

Full details are available in the SEF tables.

In year 2015 there were received the SEF comparison report "CR_RREG1_LV_2014" prepared by the international transaction log (ITL) administrator that provides information on the outcome of the comparison of data contained in the LV SEF tables with corresponding records contained in the ITL. There were not provided reports R2-R5 as there were no discrepancies in this report in 2014.

## 12.3 Discrepancies and notifications

### 12.3.1 List of discrepant transactions

No discrepant transactions rejected and / or terminated with the response codes that are considered to be a discrepancy for the purpose of the reporting occurred in 2015 in Latvia's ETR.

No transactions in Latvia's ETR were cancelled or terminated.

### 12.3.2 List of CDM notifications

CDM notifications – reversal of storage notifications, non-certification notifications were not received in the reporting period 2015.

### 12.3.3 List of non-replacements

No non-replacement occurred during reporting period 2015.

### 12.3.4 List of invalid units

There weren't any invalid units in Latvia's ETR in the reporting period from 1st January 2015 to 31st December 2015.

### 12.3.5 Actions and changes to address discrepancies

There weren't any discrepant transactions that were not terminated and / or cancelled in Latvia's ETR during reporting period 2015.

## 12.4 Publicly accessible information

The information required to be publicly accessible by the decisions 13/CMP/1 is available on the national administrator of Emission registry web page: http://www.meteo.lv/en/lapas/submission-under-unframework-of-climate-change-convention-conference-?id=1476&nid=646

As well as on the Emission Registry of Latvia public webpage:

https://ets-registry.webgate.ec.europa.eu/euregistry/LV/public/reports/publicReports.xhtml

The information on the accounts is also available on the European Commission webpage: http://ec.europa.eu/environment/ets/account.do;EUROPA_JSESSIONID=zyE_PpHqLkqmy0rOOeWALmfWfvpML4wVYw-l5j2-LwzuDy-fQcAX!-198553537?languageCode=lv&account.registryCodes=LV&accountHolder=&search=Search&searchType=account&currentSortSettings=

According to Article 44-48 of the decision 13CMP.1 Annex E the following information has to be publicly available:

Article 45 – Information about the accounts opened in Latvia's Emission trading registry, account types, account holders and contact persons has been published in file "Latvia's registry".

Article 46 – Information about Article 6 project against which the Party has issued ERUs.

Article 47 – Information of the Kyoto Protocol units in the Latvia's Emission Trading registry opened accounts as well as transactions of Kyoto Protocol units is submitted in Standard Electronic Format.

Article 48 - Legal entities authorized to participate in the mechanisms under Articles 6, 12 and 17 of the Kyoto Protocol.

## *12.5 Calculation of the commitment period reserve (CPR)*

Parties are required by decision 11/CMP.1 under the Kyoto Protocol and paragraph 18 of Decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8.

Both methods are used for calculation of commitment period reserve.

1) 100% of most recently reviewed inventory, multiplied by 8:

CPR = 10,979,650 tonnes $CO_2$ eq * 8 = 87,837,200 tonnes $CO_2$ eq.

2) 90% of a Latvia`s assigned amount pursuant to Article 3(7bis), (8) and (8bis):

CPR = 76,633,439 tonnes $CO_2$ eq * 90% = 68,970,095 tonnes $CO_2$ eq

The commitment period reserve equals the lower figure from both calculated, therefore Latvia`s commitment period reserve is 68,970,095 tonnes $CO_2$ eq.

## *12.6 KP-LULUCF accounting*

Latvia has chosen accounting of all KP-LULUCF activities regarding Articles 3.3. (Aforestation, Reforestation and deforestation) and 3.4 (Forest Management) at the end of commitment period. Latvia has not elected any voluntary Kyoto Protocol LULUCF activities for the second commitment period.

Additions to the assigned amount resulting from forest management under Article 3, paragraph 4 (FM cap) in the second commitment shall not exceed 3.5 per of the base year emissions.

Latvias FM cap is calculated following:

26256.4348313065 tonnes $CO_2$ eq without LULUCF * 3,5 /100 = 918.975219095727 kt $CO_2$ eq = 918975.219095727 t $CO_2$ eq.

For the whole second commitment period the additions to the assigned amount resulting from Forest management can be 7351801.75276582 tonnes $CO_2$ eq.

# 13 INFORMATION ON CHANGES IN NATIONAL SYSTEM

According to the Cabinet of Ministers Regulation No. 217 "Regulations regarding the National Inventory System of Greenhouse Gas Emission Units" Latvian State Forest Research Institute "Silava" is responsible for GHG emissions from LULUCF and KP-LULUCF sectors at national level. For GHG inventory preparation regarding LULUCF and KP-LULUCF sectors the expert capacity has increased.

Capacity of expert`s knowledge in all GHG inventory sectors has also increased through experience sharing events within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy " in 2015 and 2016.

# 14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of Latvia has occurred in 2015.

| Reporting Item | Description |
|---|---|
| 15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact | No changes of name or contact information in the registry following 32(a) during the reported period and previous period. |
| 15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement | No change of cooperation arrangement occurred during the reported period. |
| 15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry | There was no change to the database structure as it pertains to KP functionality in 2015.<br>Versions of the CSEUR released after 6.3.3.2 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database.<br>These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model is provided in Annex A.<br>No change to the capacity of the national registry occurred during the reported period.<br>In NIR submission 2016 there are attached AnnexA_resubmission, AnnexB_resubmission and AnnexH_resubmission that contain changes referring to year 2014 and AnnexA, AnnexB that contains changes for year 2015.<br>AnnexA_resubmission and AnnexA contain the same information as there are no changes in database structure in this reporting period comparing with previous year. |
| 15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards | Changes introduced since version 6.3.3.2 of the national registry are listed in Annex B.<br>Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing will be carried out in February 2016 and the test report will be submitted thereafter<br>No other change in the registry's conformance to the technical standards occurred for the reported period. |
| 15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures | No change of discrepancies procedures occurred during the reported period. |
| 15/CMP.1 annex II.E paragraph 32.(f) Change regarding security | No change of security measures occurred during the reporting period. |
| 15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information | No change to the list of publicly available information occurred during the reporting period. |

| Reporting Item | Description |
|---|---|
| 15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address | No change of the registry internet address occurred during the reporting period. |
| 15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures | No change of data integrity measures occurred during the reporting period. |
| 15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results | Changes introduced since version 6.3.3.2 of the national registry are listed in Annex B. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission; the report is attached as Annex B.<br>Annex H testing will be carried out in February 2016 and the test report will be submitted thereafter. |
| The previous Annual Review recommendations | See table below. |

In response to the previous Annual Review recommendations and to the Standard Independent Assessment Report (IAR/2015/LVA/1/2 and IAR/2015/LVA/2/2), the following table was submitted as a second addendum to Chapter 14: 'Information on changes in national registry 'of the Annual Inventory Submission for the reporting year 2014.

| Reference | Recommendation description | Response |
|---|---|---|
| P1.2.14 | The Party didn't report the calculation of its commitment period reserve (CPR) in [NIR]. | Latvia`s 2015 submission was the official submission under the UNFCCC. The 2015 submission was not an official submission under the Kyoto Protocol therefore calculation of the commitment period reserve has not been included in the 2015 NIR by Latvia. Information on CPR is included in this 2016 submission. |
| P1.4.1<br>P1.4.1.1.<br>P1.4.1.2 | The assessor was able to locate only information pertaining to operator holding accounts at the first link mentioned. No other information on Party holding accounts, retirement and cancellation accounts is included. The assessor recommends the Party include this information in the first link mentioned. | Information is updated – Account information is provided on the web pages :<br>Article 45 – Information about the accounts opened in Latvia's registry has been published http://www.meteo.lv/en/lapas/submission-underunframework-of-climate-change-convention-conference-?id=1476&nid=646 file "Latvia' registry" According to last SIAR report and previous report findings that were reiterated referring to publicly available information, there were made updates and provided additional information in above mentioned webpage http://www.meteo.lv/en/lapas/submission-under-unframework-of-climate-change-convention-conference-?id=1476&nid=646<br>There is updated information under UN Framework of Climate Change Convention Conference of the Parties decision 13/CMP.1 |

| Reference | Recommendation description | Response |
|---|---|---|
| | | Annex E requirements Article 45- Information about the accounts opened in Latvia's Emission trading registry, account types, account holders and contacts. There is updated pdf file "Latvia's registry" that contains information according to 13/CMP.1 Annex E Article 45 (a, b and c). |
| P1.4.1.3 | The assessor was not able to locate information on account commitment period at the first link mentioned. The assessor recommends the Party include this information in the first link mentioned | Information is updated: the commitment period with which a cancellation or retirement account is associated provided on the web pages http://www.meteo.lv/en/lapas/submission-underunframework-of-climate-change-convention-conference-?id=1476&nid=646 |
| P1.4.1.4<br>P.1.4.1.5 | The assessor was not able to locate information on account representatives at none of the links mentioned. The assessor suktests the Party include an explicit reference to this confidentiality in the public information webpage. | In line with the data protection requirements of Regulation (EC) No 45/2001 and Directive 95/46/EC and in accordance with Article 110 and Annex XIV of Commission Regulation (EU) no 389/2013, the information on account representatives, account holdings, account numbers, all transactions made and carbon unit identifiers, held in the EUTL, the Union Registry and any other KP registry (required by paragraph 45) is considered confidential.<br>In accordance 13/CMP.1 Annex paragraph 45 (d and e) and taking into account Latvia's Latvia Law of Personal Data Protection all information regarding the account representatives is confidential and don't provide relevant information publically available according to national Law of Personal Data Protection. |
| P1.4.2.3 | The Party informed that there were no projects in accordance to 13/CMP.1 Annex paragraph 46 (c) Article 6 in 2014 and that only one Joint Implementation project "The Liepaja Regional Solid Waste Management Project" is registered on 2012. The information of the project is available in the UNFCCC webpage http://ji.unfccc.int/JIITLProject/DB/JFNQL CBVKMHCWY7HVH1YC7610UVHOD/details however assessor was still unable to locate the years of ERU issuance for this project. The assessor recommends that the Party clearly provide this information even if the result is that no ERUs have been issued. | As well there are updated information according to 13/CMP.1 Annex E Article 47 and 48 requirements.<br>There was no projects accordance to 13/CMP.1 Annex paragraph 46(c) Article 6 in 2014.<br>Information is updated: http://www.meteo.lv/en/lapas/submission-under-unframework-of-climate-change-convention-conference-?id=1476&nid=646 |
| P.1.5.3.2. | The assessor couldn't find the relevant information in the link provided. The assessor could find the updated information at https://etsregistry.webgate.ec.europa.eu/euregistry/LV/public/reports/publicReports.xhtml The assessor recommends the Party refers to this url in the next annual | Information about the accounts opened in Latvia's registry, has been updated and added http://www.meteo.lv/en/lapas/submission-underunframework-of-climate-change-convention-conference-?id=1476&nid=646<br>The Party also refers to this url https://etsregistry.webgate.ec.europa.eu/euregistry/LV/public/reports/publicReports.xhtml in |

| Reference | Recommendation description | Response |
|---|---|---|
| | submission. | this annual submission. |
| P.1.5.3.3 | The SIAR assessor recommends Party includes information on the commitment periods of accounts as required by 13/CMP.1 Annex paragraph 45 (c) | Information is updated: the commitment period with which a cancellation or retirement account is associated provided on the web pages http://www.meteo.lv/en/lapas/submission-underunframework-of-climate-change-convention-conference-?id=1476&nid=646 |
| P2.4.1.1 | The ERT recommends that Latvia clarifies what changes have been made to the national registry (regarding the information on the registry administrators) | Latvia has clarified such information in NIR and has reported an incorrect description in the previous submission related to the changes to the information for the Registry Administrator. |
| P2.4.1.2 | The assessor recommends the Party include a specific paragraph/reference in NIR to address ERT recommendations. | Done. |
| P2.4.1.3 | The ERT recommends that Latvia addresses the recommendations contained in the SIAR (FCCC/ARR/2014/LVA para. 110). | Latvia has included in this NIR submission this information referring on the SEF tables and the SEF comparison report in the 12.2 point. |
| P2.4.2.1 | The SIAR assessor recommends that Party include information on its commitment period reserve in its next annual submission. | The information on its commitment period reserve is included in this NIR |
| P2.4.2.6 | Assessor cannot locate [Annex A, B and H] referenced in the Party's submission. There were described changes and there were reference to Annex A, B and H in chapter 14 but there were not attached these annexes to NIR submission 2015. | In NIR submission 2016 there are attached AnnexA_resubmission, AnnexB_resubmission and AnnexH_resubmission that contain changes referring to year 2014 |

# 15 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Latvia as Annex I country provides the following information how Latvia is striving, under Article 3, paragraph 14, minimize adverse social, environmental and economic impacts on developing countries in accordance with the guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol (Decision 15/CMP.1, paragraph 24).

Latvia is acting together with other Parties in the EU to fulfil the commitments under the Protocol.

As reported by the *Energy Development Guidelines 2016-2020*, future energetics policy will be built according to the following principles: integration of the EU energetics and climat policy's targets in the national policy, regional cooperation with the Baltic Sea countries, Energy accessibility for users with a relatively low level of income, GHG emission reduction-oriented sustainable policy.

Parties included in Annex I that are in the position to do so, shall incorporate information on how they give priority, in implementing their commitments under Article 3, paragraph 14, to the following 6 actions, based on relevant methodologies referred to in paragraph 11 of decision 31/CMP.1

**(a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities**

*Energy sector*

As already mentioned in the last years' report, Latvia agreed on the long term strategy for energy until 2030 – a competitive energy for society, focusing also on sustainable energy. The main target of the Strategy is to promote competitive economy by creating balanced, effective, economically, socially and environmentally justified and market-based energy policy.

- According to Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources, Latvia has got one of the highest individual targets for the share of renewable energy by 2020, namely 40% from total gross final energy consumption. In 2013, the rate was already about 37.1 %, what positioned Latvia on number 2 in the EU after Sweden. In 2014, this rate was already 38, 65%.
- The share of renewable energy in the transport sector must reach at least 10% by 2020 of gross final energy consumption for transport (in 2010 it comprised 3.3%, in 2011 – 3.2%, in 2012 – 3.1%). One of the ways how to reach this target is the use of electric vehicules. Latvia is starting to work on the infrastructure of electric vehicule charging stations: *Electromobility development plan 2014-2016* has been approved by the Cabinet of Ministers on 26 March 2014 (order Nr. 129). Taking into account

the estimated number of registred electric vehicles in the country, it would be necessary to install about 235 such charging stations. Till 2020 Latvia has several plans also about the electrification of the public transport system, essentially in the capital Riga, including railway electrification.

- Alternative energy is a crucial source of energy for the future. Based on the consultation of stakeholders and national experts, as well as the expertise reflected in the Communication from the Commission of 24 January 2013 entitled 'Clean Power for Transport: A European alternative fuels strategy', hydrogen was identified as one of the principal alternative fuels with a potential for long-term oil substitution. The use of hydrogen could be an effective solution because of the abundant water resources in Latvia. In respect of the DIRECTIVE 2014/94/EU, the Municipality of Riga has joined the Hydrogen Fuel cells and Electro-mobility in European regions (HvER) and participates to several international projects, including the creation of a hydrogen fuel station in the capital of Riga. Several national-level programs in research on hydrogen fuel cells have been launched in cooperation with the local universities.
- On 1st January 2015, the electroenergy market was opened also for households, as it is required by the amendments of the Energy Market Law of 20 March 2014. Along with the opening of the electricity market for households, the market came to approximately 847 300 users, represneting about 90% of the total amount of users. Not all households in the price of electricity are longer subsidiesed. The reduced price of electricity is provided at the most vulnerable groups of society – poor or low income families (persons), families with disabled children, persons with disabilities, and the first group of large families (the electricity price diference is subsidized).
- Latvia has introduced a national support mechanism for renewable energies – mandatory procurement and guarenteed payement for the installed electrical capacity. Costs incurred in support of RES or high-efficiency cogeneratrion production of electricity are covered by Latvian electricity end-users in proportion to their consumption of electricity as in the price is included mandatory procurement components (OIK). It is projected that the OIK will increase till 2017 when the state support is going to expire. In order to maintain the support for producing the energy from RES or high-efficiency cogeneration installations, and to leave the OIK at the 2013 level, (26.79 EUR/MWh), Subsidized Energy Tax (SEN) is in force since 1st January 2014. It can be applied till the 31st December 2017. This tax is laid down ir 3 different rates: 15% for natural gas cogeneration plants, 10% for RES –using stations, 5% for stations that have particular conditions.

*Environmental taxes*

Environmental taxes are intended to grow in the years to follow: according to European Comission *Study on Environmental Fiscal Reform Potential in 14 EU Member States,* the potential revenue generated from the increase of the environmental taxes could reach 2.47% from the Latvian GDP by 2025, comparing to 2.42% in 2012.In the therms of money, it could reach 642 millions of euros by 2025 (real 2014 terms).

- Any emission of air pollutants (including $CO_2$) which is outside of transferred allowances is taxed according to the Natural Resources Tax Law. A number of these rates have increased steadily since 2007. $CO_2$ from stationary technological installations (except those covered by exemptions outlined in the Law on Pollution 405) 2014 rate: €2.85 per tonne; 2015 rate: €3.50 per tonne; $PM_{10}$ (not containing heavy metals): 2014 rate: €51.22 per tonne; 2015 rate: €75.00 per tonne.
- Since the 1st January 2014, there is an additional tax on the sale of coal, coke and lignite. If the thermal input is known, the tax is €0.30 per GJ; and if the thermal input is unknown, the tax is €8.54 per tonne.

**(b) Removing subsidies associated with the use of environmentally unsound and unsafe Technologies.**

No changes in subsidies for environmentally unsound and unsafe technologies have been identified in 2014.

**(c) Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end**

The technological development of non-energy uses of fossil fuels is not a priority for Latvia at this moment.

**(d) Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort.**

Each year there is a new Assitance Development Plan worked out by the Ministry of Foreign Affairs. Latvian priority countries in the development assistance for 2014 were UE East partnership countries (Belarus, Georgia, Moldova and Ukraine) and the Central Asia countries (Kyrgyzstan, Tajikistan and Uzbekistan).

In 2014, the budget funding for the bilateral development assistance was 213 813 EUR. With this budjet funding, there has been a continuation to the cooperation project between the Ministry of Environmental protection and Regional development of Latvia (MEPRD) and the Republic of Moldova (mentioned in the last year's report) in the field of regional planning. Taking into account the positive results of the Moldova's North Region development program, what is now an example program for other regions of the country, the cooperation in 2014 was financed in the same amount as in 2012 and 2013.

According to the Assitance Development Plan for 2014, there has been a call for grant project proposals to finance bilateral cooperation projects in the Latvian priority countries in the UE East partnership countries and Central Asia. In 2014, the financal support for these projects was 70 000 EUR.

2014 was also the preparation year for the Latvian Presidency in the EU Council and for the European Thematic year, which was devoted to the development assistance theme. There has been some participation of the Environmental NGO sector.

Latvia is interested to participate in the implementation of international and regional level cooperation plans in the energy sector. There is an active cooperation in the scientific sector on a regional and EU level.

- As a member of the European Union, Latvia is also taking part in the work of the Energy Community, beeing a part of its objective to improve the environmental situation in relation with the energy supply.
- Latvian partners are implicated in the European Comission supported program „Intelligent Energy Europe" (IEE) Project Transparense. Its objective is to increase the transparense of the Energy performance certificates (EPC).
- Latvia has a good cooperation with Norway. To increase "green" business competitiveness, including the competitiveness of enterprises and the "green" innovation, "a project called "Green innovation" has been implemented with the financement of the Norwegian Financial Mechanism during 2009-2014. The program was implemented by the program intermediary - Ministry of Economics of Latvia in cooperation with Investment and Development Agency of Latvia (LIAA) and a donnor-country program partner - the Royal Norwegian state-owned enterprise "Innovation Norway" (Innovation Norway).

**(e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities.**

There is no direct action taken in the context of cooperation with developing countries in the energy sector. Nevertheless, Latvia is continuing to make efforts in the increase of local origin energy fuels, strengthening its energetical independance while reducing the potential negative impact of the imported fossil resources.

In 2013 local energy provided 34.9% of the total primary energy consumption. Most of them were RES - wood biomass, hydro, wind, biogas, biofuels and local energy resources - peat, waste. There is still a potential for peat extraction energy and for waste use in the production of energy.

The rest of the part or 65.1% of energy resources in 2013, among which the most important were oil and natural gas, were imported from the Baltic region, the EU and third countries, including from Russia. Natural gas was supplied only from Russia, which accounted for 26.9%. Imported energy from other countries than Russia or EU countries is about 0,4%, and it is electricity.

**(f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies.**

There have been no direct assistance projects in 2014 to diversify developing countries' economies, although, Latvia is taking part in these actions by working in connexion with such international organizations like OECD. Latvia has started its way to OECD since the invitation to start negotiations on 30 May 2013. Joining OECD will also increase Latvia's responsabilities in the field of renewable energy. OECD Environment Policy Committee and its subgroups were assessed in the context of compliance with the Latvian 44 OECD policy instruments applicable to the broader environmental policies, like energy choice, air pollution control, energy use in households and the production sector, environmental mitigation, environmental aspects of development cooperation and others. MEPRD and other public authorities are actively involved in the OECD Environment Policy Committee subgroup of Climate, investment and development, and other subgroups. Becoming member of OECD, Latvia could also have the possibility to join the International Energy Agency.

In 2014, Latvia devoted 0.08% of the gross national income (GNI) or about ~ 18.4 million for the development assistance. Each year, Latvia accounts for the Official Development Assistance (ODA) by using OECD's Development Assistance Committee guidelines.

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# ANNEXES TO THE NATIONAL INVENTORY REPORT

## *Annex 1: Key categories*

### A.1.1. Spreadsheet for the Approach 1 analysis for 1990 – level assessment with LULUCF

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass | $CO_2$ | -19117.243 | 19117.243 | 0.337 | 34% |
| 4.A.1 Forest Land remaining Forest Land – Drained organic soil | $CO_2$ | 4125.549 | 4125.549 | 0.073 | 41% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.621 | 3049.621 | 0.054 | 46% |
| 4.B.1 Cropland remaining Cropland – Drained organic soil | $CO_2$ | 2761.365 | 2761.365 | 0.049 | 51% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.319 | 2644.319 | 0.047 | 56% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.989 | 2117.989 | 0.037 | 60% |
| 3.D.1. Direct N2O emissions from managed soils | $N_2O$ | 1962.776 | 1962.776 | 0.035 | 63% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.750 | 1723.750 | 0.030 | 66% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.785 | 1410.785 | 0.025 | 69% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CO_2$ | 1016.928 | 1016.928 | 0.018 | 70% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.294 | 1007.294 | 0.018 | 72% |
| 4.C.1 Grassland remaining Grassland – Drained organic soil | $CO_2$ | 924.833 | 924.833 | 0.016 | 74% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.206 | 798.206 | 0.014 | 75% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.704 | 795.704 | 0.014 | 77% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.531 | 778.531 | 0.014 | 78% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.076 | 695.076 | 0.012 | 79% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.136 | 616.136 | 0.011 | 80% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.818 | 605.818 | 0.011 | 81% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $N_2O$ | 567.422 | 567.422 | 0.010 | 82% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.380 | 531.380 | 0.009 | 83% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.169 | 524.169 | 0.009 | 84% |
| 5.A.2. Unmanaged Waste Disposal | $CH_4$ | 392.831 | 392.831 | 0.007 | 85% |

| **IPCC category/Group** | **Gas** | **1990 emissions or removals (kt $CO_2$ eq)** | **Absolute value of 1990 emissions or removals (kt $CO_2$ eq)** | **Level assessment** | **Cumulative total of Level assessment** |
|---|---|---|---|---|---|
| Sites | | | | | |
| 3.D.2 Indirect N2O Emissions from managed soils | $N_2O$ | 377.223 | 377.223 | 0.007 | 86% |
| 4.B.2 Land converted to Cropland – Carbon stock change, forest land converted to cropland | $CO_2$ | 373.356 | 373.356 | 0.007 | 86% |
| 3.G. Liming | $CO_2$ | 371.419 | 371.419 | 0.007 | 87% |
| 2.A.1. Cement Production | $CO_2$ | 370.804 | 370.804 | 0.007 | 88% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 334.009 | 334.009 | 0.006 | 88% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.911 | 329.911 | 0.006 | 89% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.484 | 314.484 | 0.006 | 89% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change –organic soils | $CO_2$ | 277.200 | 277.200 | 0.005 | 90% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.679 | 276.679 | 0.005 | 90% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.577 | 273.577 | 0.005 | 91% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CO_2$ | 256.178 | 256.178 | 0.005 | 91% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.464 | 234.464 | 0.004 | 92% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.601 | 219.601 | 0.004 | 92% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 218.053 | 0.004 | 92% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 207.775 | 0.004 | 93% |
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 177.238 | 0.003 | 93% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.222 | 174.222 | 0.003 | 93% |
| 4. G. Harvested wood products | $CO_2$ | -166.356 | 166.356 | 0.003 | 94% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.415 | 149.415 | 0.003 | 94% |
| 2.A.2. Lime Production | $CO_2$ | 148.857 | 148.857 | 0.003 | 94% |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | 147.054 | 147.054 | 0.003 | 94% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.827 | 142.827 | 0.003 | 95% |
| 3.B.5 Indirect N2O emissions from Manure Management | $N_2O$ | 137.520 | 137.520 | 0.002 | 95% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 137.025 | 137.025 | 0.002 | 95% |
| 4.B. Cropland remaining cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 125.098 | 125.098 | 0.002 | 95% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 120.666 | 120.666 | 0.002 | 96% |
| 4.E.2 Land converted to Settlements – Carbon stock change – living biomass | $CO_2$ | 115.903 | 115.903 | 0.002 | 96% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.967 | 110.967 | 0.002 | 96% |
| 1.A.2.e Food Processing, Beverages | $CO_2$ | 103.071 | 103.071 | 0.002 | 96% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| and Tobacco - Solid Fuels | | | | | |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.282 | 102.282 | 0.002 | 96% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.425 | 96.425 | 0.002 | 97% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.252 | 93.252 | 0.002 | 97% |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood | $CO_2$ | 77.311 | 77.311 | 0.001 | 97% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.839 | 73.839 | 0.001 | 97% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344 | 70.344 | 0.001 | 97% |
| 4.C. Grassland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 69.988 | 69.988 | 0.001 | 97% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.185 | 69.185 | 0.001 | 97% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.545 | 66.545 | 0.001 | 97% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.378 | 65.378 | 0.001 | 98% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – living biomass | $CO_2$ | -65.311 | 65.311 | 0.001 | 98% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | 61.352 | 61.352 | 0.001 | 98% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.201 | 61.201 | 0.001 | 98% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 56.126 | 56.126 | 0.001 | 98% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.596 | 52.596 | 0.001 | 98% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.541 | 52.541 | 0.001 | 98% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – living biomass | $CO_2$ | -48.284 | 48.284 | 0.001 | 98% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.030 | 48.030 | 0.001 | 98% |
| 4.E.2 Land converted to Settlements – Carbon stock change – dead organic matter | $CO_2$ | 45.651 | 45.651 | 0.001 | 98% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.699 | 44.699 | 0.001 | 98% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.269 | 43.269 | 0.001 | 99% |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.272 | 42.272 | 0.001 | 99% |
| 2.D.3. Solvent Use | $CO_2$ | 41.064 | 41.064 | 0.001 | 99% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 40.753 | 40.753 | 0.001 | 99% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 39.135 | 0.001 | 99% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.957 | 36.957 | 0.001 | 99% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.920 | 32.920 | 0.001 | 99% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CH_4$ | 28.534 | 28.534 | 0.001 | 99% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263 | 27.263 | 0.000 | 99% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CH_4$ | 25.205 | 25.205 | 0.000 | 99% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.779 | 24.779 | 0.000 | 99% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687 | 24.687 | 0.000 | 99% |
| 5.B.1. Composting | $CH_4$ | 23.909 | 23.909 | 0.000 | 99% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.424 | 23.424 | 0.000 | 99% |
| 2.D.1 Lubricant Use | $CO_2$ | 23.251 | 23.251 | 0.000 | 99% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.986 | 22.986 | 0.000 | 99% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – living biomass | $CO_2$ | -19.180 | 19.180 | 0.000 | 99% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.091 | 18.091 | 0.000 | 99% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.617 | 17.617 | 0.000 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.155 | 17.155 | 0.000 | 99% |
| 5.B.1. Composting | $N_2O$ | 17.100 | 17.100 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.429 | 16.429 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.547 | 15.547 | 0.000 | 100% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – dead organic matter | $CO_2$ | -13.810 | 13.810 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 13.074 | 13.074 | 0.000 | 100% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.485 | 12.485 | 0.000 | 100% |
| 4.B.2 Land converted to Cropland – Drained organic soil | $CO_2$ | 12.456 | 12.456 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.150 | 9.150 | 0.000 | 100% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 8.944 | 8.944 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 8.109 | 0.000 | 100% |
| 3.H. Urea Application | $CO_2$ | 7.709 | 7.709 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.163 | 7.163 | 0.000 | 100% |
| 4.B.2 Land converted to Cropland – Mineral soil | $CO_2$ | 6.935 | 6.935 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.666 | 6.666 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 6.220 | 6.220 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 4.B.1 Cropland remaining Cropland – Carbon stock change – living biomass | $CO_2$ | -6.124 | 6.124 | 0.000 | 100% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – dead organic matter | $CO_2$ | -6.108 | 6.108 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.594 | 5.594 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.286 | 5.286 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.847 | 4.847 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – dead organic matter | $CO_2$ | -4.284 | 4.284 | 0.000 | 100% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $N_2O$ | 3.793 | 3.793 | 0.000 | 100% |
| 4.E.2 Land converted to Settlements – Organic soils | $CO_2$ | 3.766 | 3.766 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.728 | 3.728 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 3.495 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.463 | 3.463 | 0.000 | 100% |
| 1.A.4.b Residential - Peat | $CH_4$ | 3.188 | 3.188 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.079 | 3.079 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.023 | 3.023 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.005 | 3.005 | 0.000 | 100% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $N_2O$ | 2.956 | 2.956 | 0.000 | 100% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.863 | 2.863 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692 | 2.692 | 0.000 | 100% |
| 4.A.1 Forest land remaining forest land - wildfires | $CH_4$ | 2.525 | 2.525 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.412 | 2.412 | 0.000 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.341 | 2.341 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.265 | 2.265 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.150 | 2.150 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.879 | 1.879 | 0.000 | 100% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.824 | 1.824 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774 | 1.774 | 0.000 | 100% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, | $CO_2$ | -1.612 | 1.612 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| carbon stock change, dead wood | | | | | |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.454 | 1.454 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.437 | 1.437 | 0.000 | 100% |
| 4.E.2 Land converted to Settlements – Mineral soils | $CO_2$ | 1.400 | 1.400 | 0.000 | 100% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, litter | $CO_2$ | -1.382 | 1.382 | 0.000 | 100% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – dead organic matter | $CO_2$ | -1.368 | 1.368 | 0.000 | 100% |
| 2.G.3. N2O from product uses | $N_2O$ | 1.302 | 1.302 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.205 | 1.205 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.108 | 1.108 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030 | 1.030 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.998 | 0.998 | 0.000 | 100% |
| 4.E.2 Lands converted to settlements, Direct nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0.911 | 0.911 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868 | 0.868 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.833 | 0.833 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.811 | 0.811 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.789 | 0.789 | 0.000 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.782 | 0.782 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.761 | 0.761 | 0.000 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.745 | 0.745 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.702 | 0.702 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.651 | 0.651 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.641 | 0.641 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.628 | 0.628 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.616 | 0.616 | 0.000 | 100% |
| 4.B.2 Land converted to cropland, | $N_2O$ | 0.590 | 0.590 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| Direct nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | | | | | |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.520 | 0.520 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.501 | 0.501 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.483 | 0.483 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.478 | 0.478 | 0.000 | 100% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455 | 0.455 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.450 | 0.450 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423 | 0.423 | 0.000 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.356 | 0.356 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 0.327 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.318 | 0.318 | 0.000 | 100% |
| 4.A.1 Forest land remaining forest land - wildfires | $N_2O$ | 0.296 | 0.296 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.296 | 0.296 | 0.000 | 100% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.287 | 0.287 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.285 | 0.285 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273 | 0.273 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.273 | 0.273 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.272 | 0.272 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.269 | 0.269 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.239 | 0.239 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CH_4$ | 0.233 | 0.233 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.218 | 0.218 | 0.000 | 100% |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.186 | 0.186 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181 | 0.181 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.173 | 0.173 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.171 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.171 | 0.171 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - | $CH_4$ | 0.168 | 0.168 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| Peat | | | | | |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.164 | 0.164 | 0.000 | 100% |
| 4.A.2 Land converted to Forest Land – Carbon stock change, grassland converted to forest land | $CO_2$ | -0.158 | 0.158 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.143 | 0.143 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127 | 0.127 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.125 | 0.125 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.124 | 0.124 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.119 | 0.119 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.107 | 0.107 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.101 | 0.101 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.095 | 0.095 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091 | 0.091 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.081 | 0.081 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079 | 0.079 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.076 | 0.076 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.069 | 0.069 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.068 | 0.068 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.058 | 0.058 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.055 | 0.055 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $N_2O$ | 0.054 | 0.054 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.054 | 0.054 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050 | 0.050 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $CH_4$ | 0.050 | 0.050 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.036 | 0.036 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034 | 0.034 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CH_4$ | 0.032 | 0.032 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.027 | 0.027 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.025 | 0.025 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and | $N_2O$ | 0.024 | 0.024 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| Other Energy Industries - Gaseous Fuels | | | | | |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.024 | 0.024 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.023 | 0.023 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020 | 0.020 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.018 | 0.018 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015 | 0.015 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.014 | 0.014 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.013 | 0.013 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.013 | 0.013 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.011 | 0.011 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.011 | 0.011 | 0.000 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.009 | 0.009 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008 | 0.008 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.007 | 0.007 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.005 | 0.005 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.004 | 0.004 | 0.000 | 100% |
| 4.C.2 Land converted to Grassland – Mineral soil | $CO_2$ | -0.003 | 0.003 | 0.000 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.003 | 0.003 | 0.000 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 4.C.2 Land converted to Grassland – Drained organic soil | $CO_2$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| Gasoline | | | | | |
| TOTAL | | 17834.80 | 56737.089 | 1.000 | |

### A.1.2. Spreadsheet for the Approach 1 analysis for 1990 – level assessment without LULUCF

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.621 | 3049.621 | 0.116 | 12% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.319 | 2644.319 | 0.101 | 22% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.989 | 2117.989 | 0.081 | 30% |
| 3.D.1. Direct N2O emissions from managed soils | $N_2O$ | 1962.776 | 1962.776 | 0.075 | 37% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.750 | 1723.750 | 0.066 | 44% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.785 | 1410.785 | 0.054 | 49% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.294 | 1007.294 | 0.038 | 53% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.206 | 798.206 | 0.030 | 56% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.704 | 795.704 | 0.030 | 59% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.531 | 778.531 | 0.030 | 62% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.076 | 695.076 | 0.026 | 65% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.136 | 616.136 | 0.023 | 67% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.818 | 605.818 | 0.023 | 69% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.380 | 531.380 | 0.020 | 71% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.169 | 524.169 | 0.020 | 73% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 392.831 | 392.831 | 0.015 | 75% |
| 3.D.2 Indirect N2O Emissions from managed soils | $N_2O$ | 377.223 | 377.223 | 0.014 | 76% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 3.G. Liming | $CO_2$ | 371.419 | 371.419 | 0.014 | 78% |
| 2.A.1. Cement Production | $CO_2$ | 370.804 | 370.804 | 0.014 | 79% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 334.009 | 334.009 | 0.013 | 80% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.911 | 329.911 | 0.013 | 82% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.484 | 314.484 | 0.012 | 83% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.679 | 276.679 | 0.011 | 84% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.577 | 273.577 | 0.010 | 85% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.464 | 234.464 | 0.009 | 86% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.601 | 219.601 | 0.008 | 87% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 218.053 | 0.008 | 88% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 207.775 | 0.008 | 88% |
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 177.238 | 0.007 | 89% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.222 | 174.222 | 0.007 | 90% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.415 | 149.415 | 0.006 | 90% |
| 2.A.2. Lime Production | $CO_2$ | 148.857 | 148.857 | 0.006 | 91% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.827 | 142.827 | 0.005 | 91% |
| 3.B.5 Indirect N2O emissions from Manure Management | $N_2O$ | 137.520 | 137.520 | 0.005 | 92% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 137.025 | 137.025 | 0.005 | 92% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 120.666 | 120.666 | 0.005 | 93% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.967 | 110.967 | 0.004 | 93% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 103.071 | 103.071 | 0.004 | 94% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.282 | 102.282 | 0.004 | 94% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.425 | 96.425 | 0.004 | 94% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.252 | 93.252 | 0.004 | 95% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.839 | 73.839 | 0.003 | 95% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344 | 70.344 | 0.003 | 95% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.185 | 69.185 | 0.003 | 96% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.545 | 66.545 | 0.003 | 96% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.378 | 65.378 | 0.002 | 96% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | 61.352 | 61.352 | 0.002 | 96% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.201 | 61.201 | 0.002 | 97% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.596 | 52.596 | 0.002 | 97% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.541 | 52.541 | 0.002 | 97% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.030 | 48.030 | 0.002 | 97% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.699 | 44.699 | 0.002 | 97% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.269 | 43.269 | 0.002 | 97% |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.272 | 42.272 | 0.002 | 98% |
| 2.D.3. Solvent Use | $CO_2$ | 41.064 | 41.064 | 0.002 | 98% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 40.753 | 40.753 | 0.002 | 98% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 39.135 | 0.001 | 98% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.957 | 36.957 | 0.001 | 98% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.920 | 32.920 | 0.001 | 98% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263 | 27.263 | 0.001 | 98% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.779 | 24.779 | 0.001 | 99% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687 | 24.687 | 0.001 | 99% |
| 5.B.1. Composting | $CH_4$ | 23.909 | 23.909 | 0.001 | 99% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.424 | 23.424 | 0.001 | 99% |
| 2.D.1 Lubricant Use | $CO_2$ | 23.251 | 23.251 | 0.001 | 99% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.986 | 22.986 | 0.001 | 99% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.091 | 18.091 | 0.001 | 99% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.617 | 17.617 | 0.001 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.155 | 17.155 | 0.001 | 99% |
| 5.B.1. Composting | $N_2O$ | 17.100 | 17.100 | 0.001 | 99% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.429 | 16.429 | 0.001 | 99% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.547 | 15.547 | 0.001 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 13.074 | 13.074 | 0.000 | 99% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.485 | 12.485 | 0.000 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.150 | 9.150 | 0.000 | 100% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 8.944 | 8.944 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 8.109 | 0.000 | 100% |
| 3.H. Urea Application | $CO_2$ | 7.709 | 7.709 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.163 | 7.163 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.666 | 6.666 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 6.220 | 6.220 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.594 | 5.594 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.286 | 5.286 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.847 | 4.847 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.728 | 3.728 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 3.495 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.463 | 3.463 | 0.000 | 100% |
| 1.A.4.b Residential - Peat | $CH_4$ | 3.188 | 3.188 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.079 | 3.079 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.023 | 3.023 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.005 | 3.005 | 0.000 | 100% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.863 | 2.863 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692 | 2.692 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.412 | 2.412 | 0.000 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.341 | 2.341 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.265 | 2.265 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.150 | 2.150 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.879 | 1.879 | 0.000 | 100% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.824 | 1.824 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774 | 1.774 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.454 | 1.454 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.437 | 1.437 | 0.000 | 100% |
| 2.G.3. N2O from product uses | $N_2O$ | 1.302 | 1.302 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.205 | 1.205 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.108 | 1.108 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030 | 1.030 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.998 | 0.998 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868 | 0.868 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.833 | 0.833 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.811 | 0.811 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.789 | 0.789 | 0.000 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.782 | 0.782 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.761 | 0.761 | 0.000 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.745 | 0.745 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.702 | 0.702 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.651 | 0.651 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.641 | 0.641 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.628 | 0.628 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.616 | 0.616 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.520 | 0.520 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.501 | 0.501 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.483 | 0.483 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.478 | 0.478 | 0.000 | 100% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455 | 0.455 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.450 | 0.450 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423 | 0.423 | 0.000 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.356 | 0.356 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 0.327 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.318 | 0.318 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.296 | 0.296 | 0.000 | 100% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.287 | 0.287 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.285 | 0.285 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273 | 0.273 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.273 | 0.273 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.272 | 0.272 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.269 | 0.269 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.239 | 0.239 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CH_4$ | 0.233 | 0.233 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.218 | 0.218 | 0.000 | 100% |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.186 | 0.186 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181 | 0.181 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.173 | 0.173 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.171 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.171 | 0.171 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.168 | 0.168 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.164 | 0.164 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.143 | 0.143 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127 | 0.127 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.125 | 0.125 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.124 | 0.124 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.119 | 0.119 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.107 | 0.107 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.101 | 0.101 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.095 | 0.095 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091 | 0.091 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.081 | 0.081 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079 | 0.079 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.076 | 0.076 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.069 | 0.069 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.068 | 0.068 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.058 | 0.058 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.055 | 0.055 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.054 | 0.054 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050 | 0.050 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.036 | 0.036 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034 | 0.034 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CH_4$ | 0.032 | 0.032 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.027 | 0.027 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.025 | 0.025 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.024 | 0.024 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.024 | 0.024 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.023 | 0.023 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020 | 0.020 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.018 | 0.018 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015 | 0.015 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.014 | 0.014 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.013 | 0.013 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.013 | 0.013 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.011 | 0.011 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.011 | 0.011 | 0.000 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.009 | 0.009 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008 | 0.008 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.007 | 0.007 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.005 | 0.005 | 0.000 | 100% |

| **IPCC category/Group** | **Gas** | **1990 emissions or removals (kt $CO_2$ eq)** | **Absolute value of 1990 emissions (kt $CO_2$ eq)** | **Level assessment** | **Cumulative total of Level assessment** |
|---|---|---|---|---|---|
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.004 | 0.004 | 0.000 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.003 | 0.003 | 0.000 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| TOTAL | | 26256.43 | 26256.43 | 1.000 | |

## A.1.3. Spreadsheet for the Approach 2 analysis for 1990 – level assessment with LULUCF

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.A.1 Forest Land remaining Forest Land – Drained organic soil | $CO_2$ | 4125.549 | 4125.549 | 5% | 25% | 0.256 | 0.073 | 0.019 | 0.097 | 10% |
| 3.D.1. Direct N2O emissions from managed soils | $N_2O$ | 1962.776 | 1962.776 | 2% | 50% | 0.500 | 0.035 | 0.017 | 0.091 | 19% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $N_2O$ | 567.422 | 567.422 | 6% | 119% | 1.193 | 0.010 | 0.012 | 0.063 | 25% |
| 4.B.2 Land converted to Cropland – Carbon stock change, forest land converted to cropland | $CO_2$ | 373.356 | 373.356 | 53% | 161% | 1.693 | 0.007 | 0.011 | 0.058 | 31% |
| 4.B.1 Cropland remaining Cropland – Drained organic soil | $CO_2$ | 2761.365 | 2761.365 | 13% | 18% | 0.227 | 0.049 | 0.011 | 0.058 | 37% |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass | $CO_2$ | -19117.243 | 19117.243 | 2% | 3% | 0.032 | 0.337 | 0.011 | 0.057 | 42% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.989 | 2117.989 | 2% | 20% | 0.201 | 0.037 | 0.008 | 0.039 | 46% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.531 | 778.531 | 2% | 50% | 0.500 | 0.014 | 0.007 | 0.036 | 50% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.E.2 Land converted to Settlements – Carbon stock change – living biomass | $CO_2$ | 115.903 | 115.903 | 20% | 295% | 2.953 | 0.002 | 0.006 | 0.032 | 53% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.621 | 3049.621 | 2% | 10% | 0.102 | 0.054 | 0.005 | 0.029 | 56% |
| 4.C.1 Grassland remaining Grassland – Drained organic soil | $CO_2$ | 924.833 | 924.833 | 26% | 19% | 0.319 | 0.016 | 0.005 | 0.027 | 59% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – living biomass | $CO_2$ | -65.311 | 65.311 | 6% | 435% | 4.352 | 0.001 | 0.005 | 0.026 | 61% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.785 | 1410.785 | 2% | 20% | 0.201 | 0.025 | 0.005 | 0.026 | 64% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CO_2$ | 1016.928 | 1016.928 | 24% | | 0.242 | 0.018 | 0.004 | 0.023 | 66% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CO_2$ | 256.178 | 256.178 | 92% | 6% | 0.922 | 0.005 | 0.004 | 0.022 | 68% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 392.831 | 392.831 | 7% | 52% | 0.525 | 0.007 | 0.004 | 0.019 | 70% |
| 3.D.2 Indirect N2O Emissions from managed soils | $N_2O$ | 377.223 | 377.223 | 2% | 50% | 0.500 | 0.007 | 0.003 | 0.017 | 72% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – living biomass | $CO_2$ | -48.284 | 48.284 | 9% | 389% | 3.896 | 0.001 | 0.003 | 0.017 | 74% |
| 3.G. Liming | $CO_2$ | 371.419 | 371.419 | 2% | 50% | 0.500 | 0.007 | 0.003 | 0.017 | 76% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change –organic soils | $CO_2$ | 277.200 | 277.200 | 24% | 55% | 0.604 | 0.005 | 0.003 | 0.015 | 77% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.319 | 2644.319 | 2% | 5% | 0.054 | 0.047 | 0.003 | 0.013 | 78% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.818 | 605.818 | 2% | 20% | 0.201 | 0.011 | 0.002 | 0.011 | 80% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 207.775 | 45% | 30% | 0.541 | 0.004 | 0.002 | 0.010 | 81% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.294 | 1007.294 | 2% | 10% | 0.102 | 0.018 | 0.002 | 0.009 | 82% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 137.025 | 137.025 | 64% | 30% | 0.707 | 0.002 | 0.002 | 0.009 | 82% |
| 4.B. Cropland remaining cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 125.098 | 125.098 | 13% | 71% | 0.722 | 0.002 | 0.002 | 0.008 | 83% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.206 | 798.206 | 2% | 11% | 0.111 | 0.014 | 0.002 | 0.008 | 84% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.704 | 795.704 | 2% | 10% | 0.102 | 0.014 | 0.001 | 0.008 | 85% |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | 147.054 | 147.054 | 53% | | 0.534 | 0.003 | 0.001 | 0.007 | 86% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.076 | 695.076 | 2% | 11% | 0.109 | 0.012 | 0.001 | 0.007 | 86% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 2.A.2. Lime Production | $CO_2$ | 148.857 | 148.857 | 2% | 50% | 0.500 | 0.003 | 0.001 | 0.007 | 87% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 56.126 | 56.126 | 5% | 119% | 1.186 | 0.001 | 0.001 | 0.006 | 88% |
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 177.238 | 32% | 0% | 0.322 | 0.003 | 0.001 | 0.005 | 88% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.282 | 102.282 | 2% | 50% | 0.500 | 0.002 | 0.001 | 0.005 | 89% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.750 | 1723.750 | 2% | 2% | 0.028 | 0.030 | 0.001 | 0.005 | 89% |
| 4.C. Grassland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 69.988 | 69.988 | 24% | 58% | 0.629 | 0.001 | 0.001 | 0.004 | 89% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 218.053 | 2% | 20% | 0.201 | 0.004 | 0.001 | 0.004 | 90% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – living biomass | $CO_2$ | -6.124 | 6.124 | 3% | 701% | 7.007 | 0.000 | 0.001 | 0.004 | 90% |
| 2.A.1. Cement Production | $CO_2$ | 370.804 | 370.804 | 10% | 5% | 0.112 | 0.007 | 0.001 | 0.004 | 91% |
| 3.B.5 Indirect N2O emissions from Manure Management | $N_2O$ | 137.520 | 137.520 | 2% | 30% | 0.301 | 0.002 | 0.001 | 0.004 | 91% |
| 3.B.2.1 Manure Management - | $N_2O$ | 120.666 | 120.666 | 25% | 20% | 0.320 | 0.002 | 0.001 | 0.004 | 91% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Cattle | | | | | | | | | | |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.967 | 110.967 | 25% | 20% | 0.320 | 0.002 | 0.001 | 0.003 | 92% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687 | 24.687 | 140% | 30% | 1.432 | 0.000 | 0.001 | 0.003 | 92% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.185 | 69.185 | 2% | 50% | 0.500 | 0.001 | 0.001 | 0.003 | 92% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.911 | 329.911 | 2% | 10% | 0.102 | 0.006 | 0.001 | 0.003 | 93% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.201 | 61.201 | 2% | 50% | 0.500 | 0.001 | 0.001 | 0.003 | 93% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.380 | 531.380 | 2% | 5% | 0.054 | 0.009 | 0.001 | 0.003 | 93% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.169 | 524.169 | 2% | 5% | 0.054 | 0.009 | 0.000 | 0.003 | 93% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.679 | 276.679 | 2% | 10% | 0.102 | 0.005 | 0.000 | 0.003 | 94% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.577 | 273.577 | 2% | 10% | 0.102 | 0.005 | 0.000 | 0.003 | 94% |
| 4. G. Harvested wood products | $CO_2$ | -166.356 | 166.356 | 15% | 0% | 0.150 | 0.003 | 0.000 | 0.002 | 94% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CH_4$ | 25.205 | 25.205 | 92% | 36% | 0.988 | 0.000 | 0.000 | 0.002 | 94% |
| 5.B.1. Composting | $CH_4$ | 23.909 | 23.909 | 29% | 100% | 1.041 | 0.000 | 0.000 | 0.002 | 95% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.030 | 48.030 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.002 | 95% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – living biomass | $CO_2$ | -19.180 | 19.180 | 5% | 122% | 1.222 | 0.000 | 0.000 | 0.002 | 95% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.269 | 43.269 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.002 | 95% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CH_4$ | 28.534 | 28.534 | 24% | 71% | 0.751 | 0.001 | 0.000 | 0.002 | 95% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.378 | 65.378 | 25% | 20% | 0.320 | 0.001 | 0.000 | 0.002 | 96% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 103.071 | 103.071 | 2% | 20% | 0.201 | 0.002 | 0.000 | 0.002 | 96% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 39.135 | 5% | 50% | 0.502 | 0.001 | 0.000 | 0.002 | 96% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 334.009 | 334.009 | 2% | 5% | 0.054 | 0.006 | 0.000 | 0.002 | 96% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.136 | 616.136 | 2% | 2% | 0.028 | 0.011 | 0.000 | 0.002 | 96% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.484 | 314.484 | 2% | 5% | 0.054 | 0.006 | 0.000 | 0.002 | 97% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.920 | 32.920 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.002 | 97% |
| 5.B.1. Composting | $N_2O$ | 17.100 | 17.100 | 29% | 90% | 0.946 | 0.000 | 0.000 | 0.001 | 97% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.827 | 142.827 | 2% | 10% | 0.102 | 0.003 | 0.000 | 0.001 | 97% |
| 4.B.2 Land converted to Cropland – Drained organic soil | $CO_2$ | 12.456 | 12.456 | 114% | 18% | 1.153 | 0.000 | 0.000 | 0.001 | 97% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.425 | 96.425 | 10% | 10% | 0.141 | 0.002 | 0.000 | 0.001 | 97% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.596 | 52.596 | 5% | 25% | 0.255 | 0.001 | 0.000 | 0.001 | 97% |
| 3.B.2.3 Manure Management - | $N_2O$ | 40.753 | 40.753 | 25% | 20% | 0.320 | 0.001 | 0.000 | 0.001 | 97% |

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|---|---|---|---|---|---|---|---|---|---|---|
| Swaine | | | | | | | | | | |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.464 | 234.464 | 2% | 5% | 0.054 | 0.004 | 0.000 | 0.001 | 98% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | 61.352 | 61.352 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.001 | 98% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.601 | 219.601 | 2% | 5% | 0.054 | 0.004 | 0.000 | 0.001 | 98% |
| 2.D.1 Lubricant Use | $CO_2$ | 23.251 | 23.251 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 98% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.541 | 52.541 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.001 | 98% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.252 | 93.252 | 2% | 10% | 0.102 | 0.002 | 0.000 | 0.001 | 98% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.222 | 174.222 | 2% | 5% | 0.054 | 0.003 | 0.000 | 0.001 | 98% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.091 | 18.091 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 98% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.986 | 22.986 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.001 | 98% |
| 4.E.2 Land converted to Settlements – Carbon stock change – dead organic matter | $CO_2$ | 45.651 | 45.651 | 20% | | 0.196 | 0.001 | 0.000 | 0.001 | 98% |
| 2.D.3. Solvent Use | $CO_2$ | 41.064 | 41.064 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.001 | 99% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.415 | 149.415 | 2% | 5% | 0.054 | 0.003 | 0.000 | 0.001 | 99% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.839 | 73.839 | 2% | 10% | 0.102 | 0.001 | 0.000 | 0.001 | 99% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.545 | 66.545 | 2% | 11% | 0.111 | 0.001 | 0.000 | 0.001 | 99% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344 | 70.344 | 10% | 0% | 0.100 | 0.001 | 0.000 | 0.001 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 13.074 | 13.074 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |
| 4.B.2 Land converted to Cropland – Mineral soil | $CO_2$ | 6.935 | 6.935 | 64% | 61% | 0.889 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263 | 27.263 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.001 | 99% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.847 | 4.847 | 43% | 100% | 1.089 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.155 | 17.155 | 2% | 30% | 0.301 | 0.000 | 0.000 | 0.000 | 99% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.485 | 12.485 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.150 | 9.150 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 99% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $N_2O$ | 3.793 | 3.793 | 24% | 112% | 1.146 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.272 | 42.272 | 2% | 10% | 0.102 | 0.001 | 0.000 | 0.000 | 99% |
| 3.H. Urea Application | $CO_2$ | 7.709 | 7.709 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 8.109 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood | $CO_2$ | 77.311 | 77.311 | 2% | 5% | 0.050 | 0.001 | 0.000 | 0.000 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.163 | 7.163 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.666 | 6.666 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.429 | 16.429 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 6.220 | 6.220 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 8.944 | 8.944 | 10% | 30% | 0.316 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.594 | 5.594 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $N_2O$ | 2.956 | 2.956 | 92% | | 0.920 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.286 | 5.286 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.779 | 24.779 | 2% | 10% | 0.102 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.699 | 44.699 | 2% | 5% | 0.054 | 0.001 | 0.000 | 0.000 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.957 | 36.957 | 2% | 5% | 0.054 | 0.001 | 0.000 | 0.000 | 100% |
| 4.E.2 Land converted to Settlements – Organic soils | $CO_2$ | 3.766 | 3.766 | 47% | 18% | 0.505 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.728 | 3.728 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 3.495 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Peat | $CH_4$ | 3.188 | 3.188 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.547 | 15.547 | 2% | 10% | 0.102 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.023 | 3.023 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.005 | 3.005 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.863 | 2.863 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 4.A.1 Forest land remaining forest land - wildfires | $CH_4$ | 2.525 | 2.525 | 37% | 36% | 0.516 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.424 | 23.424 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.412 | 2.412 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.265 | 2.265 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.150 | 2.150 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.B.2 Land converted to cropland, Direct nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0.590 | 0.590 | 64% | 151% | 1.639 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.617 | 17.617 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.879 | 1.879 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 4.E.2 Land converted to Settlements – Mineral soils | $CO_2$ | 1.400 | 1.400 | 22% | 60% | 0.639 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774 | 1.774 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.341 | 2.341 | 23% | 30% | 0.378 | 0.000 | 0.000 | 0.000 | 100% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – dead organic matter | $CO_2$ | -13.810 | 13.810 | 6% | | 0.059 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.454 | 1.454 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.437 | 1.437 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.824 | 1.824 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.079 | 3.079 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.205 | 1.205 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692 | 2.692 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 100% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – dead organic matter | $CO_2$ | -6.108 | 6.108 | 9% | | 0.087 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030 | 1.030 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.998 | 0.998 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.811 | 0.811 | 43% | 40% | 0.587 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868 | 0.868 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.789 | 0.789 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.463 | 3.463 | 10% | 5% | 0.112 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.E.2 Lands converted to settlements, Direct nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0.911 | 0.911 | 20% | 38% | 0.425 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.761 | 0.761 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.745 | 0.745 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.702 | 0.702 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.108 | 1.108 | 2% | 30% | 0.301 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.651 | 0.651 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.641 | 0.641 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.628 | 0.628 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.616 | 0.616 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.356 | 0.356 | 2% | 86% | 0.860 | 0.000 | 0.000 | 0.000 | 100% |
| 3.B.1.2 Manure Management - | $CH_4$ | 0.782 | 0.782 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Sheep | | | | | | | | | | |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.520 | 0.520 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.501 | 0.501 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.483 | 0.483 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.478 | 0.478 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455 | 0.455 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.450 | 0.450 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – dead organic matter | $CO_2$ | -4.284 | 4.284 | 5% | | 0.050 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423 | 0.423 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 0.327 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.318 | 0.318 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.296 | 0.296 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.287 | 0.287 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.285 | 0.285 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273 | 0.273 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.272 | 0.272 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.273 | 0.273 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.269 | 0.269 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, dead wood | $CO_2$ | -1.612 | 1.612 | 8% | | 0.080 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.239 | 0.239 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CH_4$ | 0.233 | 0.233 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, litter | $CO_2$ | -1.382 | 1.382 | 8% | | 0.080 | 0.000 | 0.000 | 0.000 | 100% |
| 4.A.1 Forest land remaining forest land - wildfires | $N_2O$ | 0.296 | 0.296 | 37% | | 0.370 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.218 | 0.218 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.186 | 0.186 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181 | 0.181 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.171 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.171 | 0.171 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.168 | 0.168 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.164 | 0.164 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 4.A.2 Land converted to Forest Land – Carbon stock change, grassland converted to forest land | $CO_2$ | -0.158 | 0.158 | 8% | 50% | 0.504 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.143 | 0.143 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127 | 0.127 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.125 | 0.125 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.124 | 0.124 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.119 | 0.119 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.107 | 0.107 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.101 | 0.101 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.095 | 0.095 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091 | 0.091 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.833 | 0.833 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.081 | 0.081 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079 | 0.079 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.076 | 0.076 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.G.3. N2O from product uses | $N_2O$ | 1.302 | 1.302 | 2% | 2% | 0.028 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.173 | 0.173 | 20% | 5% | 0.206 | 0.000 | 0.000 | 0.000 | 100% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – dead organic matter | $CO_2$ | -1.368 | 1.368 | 3% | | 0.026 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.068 | 0.068 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.058 | 0.058 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.054 | 0.054 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.C.1 Grassland remaining Grassland, wildfires | $N_2O$ | 0.054 | 0.054 | 10% | 48% | 0.490 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050 | 0.050 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $CH_4$ | 0.050 | 0.050 | 10% | 39% | 0.403 | 0.000 | 0.000 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.069 | 0.069 | 10% | 25% | 0.269 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.036 | 0.036 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034 | 0.034 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CH_4$ | 0.032 | 0.032 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.027 | 0.027 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.025 | 0.025 | 10% | 50% | 0.510 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.024 | 0.024 | 10% | 50% | 0.510 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.024 | 0.024 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid | $CH_4$ | 0.023 | 0.023 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Fuels | | | | | | | | | | |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020 | 0.020 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.018 | 0.018 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015 | 0.015 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.014 | 0.014 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.013 | 0.013 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.013 | 0.013 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.011 | 0.011 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008 | 0.008 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.007 | 0.007 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.055 | 0.055 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.009 | 0.009 | 32% | 0% | 0.322 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.005 | 0.005 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |

| **IPCC category/Group** | **Gas** | **1990 emissions or removals (kt $CO_2$ eq)** | **Absolute value of 1990 emissions or removals (kt $CO_2$ eq)** | **Activity data uncertainty** | **Emission factor / estimation parameter uncertainty** | **Combined uncertainty** | **Level Assessment** | **Level Assessment with Uncertainty** | **Contribution to Level Assessment** | **Cumulative Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.004 | 0.004 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 4.C.2 Land converted to Grassland – Mineral soil | $CO_2$ | -0.003 | 0.003 | 10% | 61% | 0.620 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.003 | 0.003 | 20% | 60% | 0.632 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.003 | 0.003 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.001 | 0.001 | 20% | 60% | 0.632 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.011 | 0.011 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 4.C.2 Land converted to Grassland – Drained organic soil | $CO_2$ | 0.001 | 0.001 | 55% | 19% | 0.583 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.003 | 0.003 | 10% | 0% | 0.100 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000 | 0.000 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| kerosene | | | | | | | | | | |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| TOTAL | | 17834.80 | 56737.089 | | | 162.446 | 1.000 | 0.191 | 1.000 | |

### A.1.4. Spreadsheet for the Approach 2 analysis for 1990 – level assessment without LULUCF

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.D.1. Direct $N_2O$ emissions from managed soils | $N_2O$ | 1962.776 | 1962.776 | 2% | 50% | 0.500 | 0.075 | 0.037 | 0.201 | 20% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.989 | 2117.989 | 2% | 20% | 0.201 | 0.081 | 0.016 | 0.087 | 29% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.531 | 778.531 | 2% | 50% | 0.500 | 0.030 | 0.015 | 0.080 | 37% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.621 | 3049.621 | 2% | 10% | 0.102 | 0.116 | 0.012 | 0.064 | 43% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.785 | 1410.785 | 2% | 20% | 0.201 | 0.054 | 0.011 | 0.058 | 49% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 392.831 | 392.831 | 7% | 52% | 0.525 | 0.015 | 0.008 | 0.042 | 53% |
| 3.D.2 Indirect $N_2O$ Emissions from managed soils | $N_2O$ | 377.223 | 377.223 | 2% | 50% | 0.500 | 0.014 | 0.007 | 0.039 | 57% |
| 3.G. Liming | $CO_2$ | 371.419 | 371.419 | 2% | 50% | 0.500 | 0.014 | 0.007 | 0.038 | 61% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.319 | 2644.319 | 2% | 5% | 0.054 | 0.101 | 0.005 | 0.029 | 64% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.818 | 605.818 | 2% | 20% | 0.201 | 0.023 | 0.005 | 0.025 | 66% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 207.775 | 45% | 30% | 0.541 | 0.008 | 0.004 | 0.023 | 68% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.294 | 1007.294 | 2% | 10% | 0.102 | 0.038 | 0.004 | 0.021 | 71% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.206 | 798.206 | 2% | 11% | 0.111 | 0.030 | 0.003 | 0.018 | 72% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.704 | 795.704 | 2% | 10% | 0.102 | 0.030 | 0.003 | 0.017 | 74% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.076 | 695.076 | 2% | 11% | 0.109 | 0.026 | 0.003 | 0.015 | 76% |
| 2.A.2. Lime Production | $CO_2$ | 148.857 | 148.857 | 2% | 50% | 0.500 | 0.006 | 0.003 | 0.015 | 77% |
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 177.238 | 32% | 0% | 0.322 | 0.007 | 0.002 | 0.012 | 78% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.282 | 102.282 | 2% | 50% | 0.500 | 0.004 | 0.002 | 0.010 | 79% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.750 | 1723.750 | 2% | 2% | 0.028 | 0.066 | 0.002 | 0.010 | 80% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 218.053 | 2% | 20% | 0.201 | 0.008 | 0.002 | 0.009 | 81% |
| 2.A.1. Cement Production | $CO_2$ | 370.804 | 370.804 | 10% | 5% | 0.112 | 0.014 | 0.002 | 0.008 | 82% |
| 3.B.5 Indirect $N_2O$ emissions from Manure Management | $N_2O$ | 137.520 | 137.520 | 2% | 30% | 0.301 | 0.005 | 0.002 | 0.008 | 83% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 120.666 | 120.666 | 25% | 20% | 0.320 | 0.005 | 0.001 | 0.008 | 84% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.967 | 110.967 | 25% | 20% | 0.320 | 0.004 | 0.001 | 0.007 | 84% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687 | 24.687 | 140% | 30% | 1.432 | 0.001 | 0.001 | 0.007 | 85% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.185 | 69.185 | 2% | 50% | 0.500 | 0.003 | 0.001 | 0.007 | 86% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.911 | 329.911 | 2% | 10% | 0.102 | 0.013 | 0.001 | 0.007 | 87% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.201 | 61.201 | 2% | 50% | 0.500 | 0.002 | 0.001 | 0.006 | 87% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.380 | 531.380 | 2% | 5% | 0.054 | 0.020 | 0.001 | 0.006 | 88% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.169 | 524.169 | 2% | 5% | 0.054 | 0.020 | 0.001 | 0.006 | 88% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.679 | 276.679 | 2% | 10% | 0.102 | 0.011 | 0.001 | 0.006 | 89% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.577 | 273.577 | 2% | 10% | 0.102 | 0.010 | 0.001 | 0.006 | 90% |
| 5.B.1. Composting | $CH_4$ | 23.909 | 23.909 | 29% | 100% | 1.041 | 0.001 | 0.001 | 0.005 | 90% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.030 | 48.030 | 2% | 50% | 0.500 | 0.002 | 0.001 | 0.005 | 91% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.269 | 43.269 | 2% | 50% | 0.500 | 0.002 | 0.001 | 0.004 | 91% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.378 | 65.378 | 25% | 20% | 0.320 | 0.002 | 0.001 | 0.004 | 91% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 103.071 | 103.071 | 2% | 20% | 0.201 | 0.004 | 0.001 | 0.004 | 92% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 39.135 | 5% | 50% | 0.502 | 0.001 | 0.001 | 0.004 | 92% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 334.009 | 334.009 | 2% | 5% | 0.054 | 0.013 | 0.001 | 0.004 | 93% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.136 | 616.136 | 2% | 2% | 0.028 | 0.023 | 0.001 | 0.004 | 93% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.484 | 314.484 | 2% | 5% | 0.054 | 0.012 | 0.001 | 0.003 | 93% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.920 | 32.920 | 2% | 50% | 0.500 | 0.001 | 0.001 | 0.003 | 94% |
| 5.B.1. Composting | $N_2O$ | 17.100 | 17.100 | 29% | 90% | 0.946 | 0.001 | 0.001 | 0.003 | 94% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.827 | 142.827 | 2% | 10% | 0.102 | 0.005 | 0.001 | 0.003 | 94% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.425 | 96.425 | 10% | 10% | 0.141 | 0.004 | 0.001 | 0.003 | 95% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.596 | 52.596 | 5% | 25% | 0.255 | 0.002 | 0.001 | 0.003 | 95% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 40.753 | 40.753 | 25% | 20% | 0.320 | 0.002 | 0.000 | 0.003 | 95% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.464 | 234.464 | 2% | 5% | 0.054 | 0.009 | 0.000 | 0.003 | 95% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | 61.352 | 61.352 | 2% | 20% | 0.201 | 0.002 | 0.000 | 0.003 | 96% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.601 | 219.601 | 2% | 5% | 0.054 | 0.008 | 0.000 | 0.002 | 96% |
| 2.D.1 Lubricant Use | $CO_2$ | 23.251 | 23.251 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.002 | 96% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.541 | 52.541 | 2% | 20% | 0.201 | 0.002 | 0.000 | 0.002 | 96% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.252 | 93.252 | 2% | 10% | 0.102 | 0.004 | 0.000 | 0.002 | 96% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.222 | 174.222 | 2% | 5% | 0.054 | 0.007 | 0.000 | 0.002 | 97% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.091 | 18.091 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.002 | 97% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.986 | 22.986 | 25% | 30% | 0.391 | 0.001 | 0.000 | 0.002 | 97% |
| 2.D.3. Solvent Use | $CO_2$ | 41.064 | 41.064 | 2% | 20% | 0.201 | 0.002 | 0.000 | 0.002 | 97% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.415 | 149.415 | 2% | 5% | 0.054 | 0.006 | 0.000 | 0.002 | 97% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.839 | 73.839 | 2% | 10% | 0.102 | 0.003 | 0.000 | 0.002 | 98% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.545 | 66.545 | 2% | 11% | 0.111 | 0.003 | 0.000 | 0.002 | 98% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344 | 70.344 | 10% | 0% | 0.100 | 0.003 | 0.000 | 0.001 | 98% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 13.074 | 13.074 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 98% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263 | 27.263 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.001 | 98% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.847 | 4.847 | 43% | 100% | 1.089 | 0.000 | 0.000 | 0.001 | 98% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.155 | 17.155 | 2% | 30% | 0.301 | 0.001 | 0.000 | 0.001 | 98% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.485 | 12.485 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.001 | 98% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.150 | 9.150 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.001 | 98% |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.272 | 42.272 | 2% | 10% | 0.102 | 0.002 | 0.000 | 0.001 | 99% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 3.H. Urea Application | $CO_2$ | 7.709 | 7.709 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 8.109 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.163 | 7.163 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.666 | 6.666 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.429 | 16.429 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.001 | 99% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 6.220 | 6.220 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 8.944 | 8.944 | 10% | 30% | 0.316 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.594 | 5.594 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.286 | 5.286 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.779 | 24.779 | 2% | 10% | 0.102 | 0.001 | 0.000 | 0.001 | 99% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.699 | 44.699 | 2% | 5% | 0.054 | 0.002 | 0.000 | 0.000 | 99% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.957 | 36.957 | 2% | 5% | 0.054 | 0.001 | 0.000 | 0.000 | 99% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.728 | 3.728 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 3.495 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.b Residential - Peat | $CH_4$ | 3.188 | 3.188 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.547 | 15.547 | 2% | 10% | 0.102 | 0.001 | 0.000 | 0.000 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.023 | 3.023 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.005 | 3.005 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.863 | 2.863 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.424 | 23.424 | 2% | 5% | 0.054 | 0.001 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.412 | 2.412 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.265 | 2.265 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.150 | 2.150 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.617 | 17.617 | 2% | 5% | 0.054 | 0.001 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.879 | 1.879 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774 | 1.774 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.341 | 2.341 | 23% | 30% | 0.378 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.454 | 1.454 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.437 | 1.437 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

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| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.824 | 1.824 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.079 | 3.079 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.205 | 1.205 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692 | 2.692 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030 | 1.030 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.998 | 0.998 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.811 | 0.811 | 43% | 40% | 0.587 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868 | 0.868 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.789 | 0.789 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.463 | 3.463 | 10% | 5% | 0.112 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.761 | 0.761 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.745 | 0.745 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.702 | 0.702 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.108 | 1.108 | 2% | 30% | 0.301 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.651 | 0.651 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.641 | 0.641 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.628 | 0.628 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.616 | 0.616 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.356 | 0.356 | 2% | 86% | 0.860 | 0.000 | 0.000 | 0.000 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.782 | 0.782 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.520 | 0.520 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.501 | 0.501 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.483 | 0.483 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.478 | 0.478 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455 | 0.455 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.450 | 0.450 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423 | 0.423 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 0.327 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.318 | 0.318 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.296 | 0.296 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.287 | 0.287 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.285 | 0.285 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273 | 0.273 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.272 | 0.272 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.273 | 0.273 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.269 | 0.269 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.239 | 0.239 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CH_4$ | 0.233 | 0.233 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.218 | 0.218 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.186 | 0.186 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181 | 0.181 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.171 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.171 | 0.171 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.168 | 0.168 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.164 | 0.164 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.143 | 0.143 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127 | 0.127 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.125 | 0.125 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.124 | 0.124 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.119 | 0.119 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.107 | 0.107 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.101 | 0.101 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.095 | 0.095 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091 | 0.091 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.833 | 0.833 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.081 | 0.081 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079 | 0.079 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.076 | 0.076 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.G.3. $N_2O$ from product uses | $N_2O$ | 1.302 | 1.302 | 2% | 2% | 0.028 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.173 | 0.173 | 20% | 5% | 0.206 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.068 | 0.068 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.058 | 0.058 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.054 | 0.054 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050 | 0.050 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.069 | 0.069 | 10% | 25% | 0.269 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.036 | 0.036 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034 | 0.034 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CH_4$ | 0.032 | 0.032 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.027 | 0.027 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.025 | 0.025 | 10% | 50% | 0.510 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.024 | 0.024 | 10% | 50% | 0.510 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.024 | 0.024 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.023 | 0.023 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020 | 0.020 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.018 | 0.018 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015 | 0.015 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.014 | 0.014 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.013 | 0.013 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.013 | 0.013 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.011 | 0.011 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008 | 0.008 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.007 | 0.007 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.055 | 0.055 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.009 | 0.009 | 32% | 0% | 0.322 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.005 | 0.005 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.004 | 0.004 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.003 | 0.003 | 20% | 60% | 0.632 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.003 | 0.003 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.001 | 0.001 | 20% | 60% | 0.632 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.011 | 0.011 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.003 | 0.003 | 10% | 0% | 0.100 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000 | 0.000 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | Absolute value of 1990 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| TOTAL | | 26256.43 | 26256.43 | | | 113.077 | 1.000 | 0.186 | 1.000 | |

### A.1.5 Spreadsheet for the Approach 1 analysis for 2014 – level assessment with LULUCF

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 4.A.1 Forest Land remaining Forest Land – Drained organic soil | $CO_2$ | 4583.281 | 4583.281 | 0.150 | 15% |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood | $CO_2$ | -3792.439 | 3792.439 | 0.124 | 27% |
| 4.B.1 Cropland remaining Cropland – Drained organic soil | $CO_2$ | 2598.777 | 2598.777 | 0.085 | 36% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 1880.266 | 1880.266 | 0.061 | 42% |
| 4. G. Harvested wood products | $CO_2$ | -1817.580 | 1817.580 | 0.059 | 48% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 1575.699 | 1575.699 | 0.052 | 53% |
| 3.D.1. Direct $N_2O$ emissions from managed soils | $N_2O$ | 1429.498 | 1429.498 | 0.047 | 58% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CO_2$ | 899.741 | 899.741 | 0.029 | 61% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 828.043 | 828.043 | 0.027 | 63% |
| 4.C.1 Grassland remaining Grassland – Drained organic soil | $CO_2$ | 684.007 | 684.007 | 0.022 | 66% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $N_2O$ | 638.801 | 638.801 | 0.021 | 68% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 613.358 | 613.358 | 0.020 | 70% |
| 2.A.1. Cement Production | $CO_2$ | 555.776 | 555.776 | 0.018 | 72% |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass | $CO_2$ | -529.092 | 529.092 | 0.017 | 73% |
| 4.C.2 Land converted to Grassland – Mineral soil | $CO_2$ | -495.257 | 495.257 | 0.016 | 75% |
| 4.E.2 Land converted to Settlements – Carbon stock change – living biomass | $CO_2$ | 480.918 | 480.918 | 0.016 | 77% |
| 4.A.2 Land converted to Forest Land – Carbon stock change, grassland converted to forest land | $CO_2$ | -341.174 | 341.174 | 0.011 | 78% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 320.575 | 320.575 | 0.010 | 79% |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 301.024 | 301.024 | 0.010 | 80% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change –organic soils | $CO_2$ | 277.200 | 277.200 | 0.009 | 81% |
| 4.C.2 Land converted to Grassland – Drained organic soil | $CO_2$ | 275.392 | 275.392 | 0.009 | 81% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 238.797 | 238.797 | 0.008 | 82% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 230.712 | 230.712 | 0.008 | 83% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 227.802 | 227.802 | 0.007 | 84% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 213.786 | 213.786 | 0.007 | 84% |
| 2.F.1. Refrigeration and air conditioning | HFCs | 206.377 | 206.377 | 0.007 | 85% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 4.E.2 Land converted to Settlements – Carbon stock change – dead organic matter | $CO_2$ | 197.497 | 197.497 | 0.006 | 86% |
| 3.D.2 Indirect $N_2O$ Emissions from managed soils | $N_2O$ | 196.044 | 196.044 | 0.006 | 86% |
| 4.E.2 Land converted to Settlements – Organic soils | $CO_2$ | 166.176 | 166.176 | 0.005 | 87% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 165.243 | 165.243 | 0.005 | 88% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – living biomass | $CO_2$ | -165.232 | 165.232 | 0.005 | 88% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 157.132 | 157.132 | 0.005 | 89% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 155.562 | 155.562 | 0.005 | 89% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 149.853 | 149.853 | 0.005 | 90% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 138.525 | 138.525 | 0.005 | 90% |
| 4.B. Cropland remaining cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 119.045 | 119.045 | 0.004 | 90% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 118.628 | 118.628 | 0.004 | 91% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 109.507 | 109.507 | 0.004 | 91% |
| 1.B.2.b Natural Gas | $CH_4$ | 109.190 | 109.190 | 0.004 | 92% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – living biomass | $CO_2$ | -108.186 | 108.186 | 0.004 | 92% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | 107.569 | 107.569 | 0.004 | 92% |
| 4.E.2 Land converted to Settlements – Mineral soils | $CO_2$ | 107.292 | 107.292 | 0.004 | 93% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 104.814 | 104.814 | 0.003 | 93% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 101.654 | 101.654 | 0.003 | 93% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 93.815 | 93.815 | 0.003 | 94% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 91.048 | 91.048 | 0.003 | 94% |
| 4.B.2 Land converted to Cropland – Drained organic soil | $CO_2$ | 89.507 | 89.507 | 0.003 | 94% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CO_2$ | 88.884 | 88.884 | 0.003 | 94% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, dead wood | $CO_2$ | -83.797 | 83.797 | 0.003 | 95% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 73.413 | 73.413 | 0.002 | 95% |
| 4.C. Grassland, Emissions and removals from drainage and rewetting and other | $CH_4$ | 72.895 | 72.895 | 0.002 | 95% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| management of organic and mineral soils | | | | | |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, litter | $CO_2$ | -71.844 | 71.844 | 0.002 | 95% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 70.595 | 70.595 | 0.002 | 96% |
| 4.A.2 Land converted to Forest Land – grassland converted to forest land, Drained organic soil | $CO_2$ | 61.248 | 61.248 | 0.002 | 96% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 55.182 | 55.182 | 0.002 | 96% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 50.233 | 50.233 | 0.002 | 96% |
| 4.B.2 Land converted to Cropland – Mineral soil | $CO_2$ | 48.750 | 48.750 | 0.002 | 96% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 45.035 | 45.035 | 0.001 | 96% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 42.947 | 42.947 | 0.001 | 97% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – living biomass | $CO_2$ | -42.877 | 42.877 | 0.001 | 97% |
| 3.B.5 Indirect $N_2O$ emissions from Manure Management | $N_2O$ | 41.938 | 41.938 | 0.001 | 97% |
| 4.E.2 Lands converted to settlements, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 40.479 | 40.479 | 0.001 | 97% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 38.502 | 38.502 | 0.001 | 97% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 34.973 | 34.973 | 0.001 | 97% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 33.544 | 33.544 | 0.001 | 97% |
| 2.D.3. Solvent Use | $CO_2$ | 32.197 | 32.197 | 0.001 | 97% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – dead organic matter | $CO_2$ | -29.466 | 29.466 | 0.001 | 98% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CH_4$ | 28.534 | 28.534 | 0.001 | 98% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 26.178 | 26.178 | 0.001 | 98% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 26.126 | 26.126 | 0.001 | 98% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 24.624 | 24.624 | 0.001 | 98% |
| 5.B.1. Composting | $CH_4$ | 22.465 | 22.465 | 0.001 | 98% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CO_2$ | 22.068 | 22.068 | 0.001 | 98% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 4.B.2 Land converted to Cropland – Carbon stock change, forest land converted to cropland | $CO_2$ | 21.176 | 21.176 | 0.001 | 98% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 21.164 | 21.164 | 0.001 | 98% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 20.646 | 20.646 | 0.001 | 98% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 20.350 | 20.350 | 0.001 | 98% |
| 3.G. Liming | $CO_2$ | 19.686 | 19.686 | 0.001 | 98% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 19.447 | 19.447 | 0.001 | 98% |
| 4.E.1 Settlements remaining Settlements – Drained organic soils | $CO_2$ | 19.430 | 19.430 | 0.001 | 99% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 18.500 | 18.500 | 0.001 | 99% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 17.427 | 17.427 | 0.001 | 99% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 17.146 | 17.146 | 0.001 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 16.555 | 16.555 | 0.001 | 99% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 16.537 | 16.537 | 0.001 | 99% |
| 5.B.1. Composting | $N_2O$ | 16.067 | 16.067 | 0.001 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 13.386 | 13.386 | 0.000 | 99% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 13.103 | 13.103 | 0.000 | 99% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 13.022 | 13.022 | 0.000 | 99% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 12.580 | 12.580 | 0.000 | 99% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 11.522 | 11.522 | 0.000 | 99% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 10.965 | 10.965 | 0.000 | 99% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 10.833 | 10.833 | 0.000 | 99% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – dead organic matter | $CO_2$ | -10.612 | 10.612 | 0.000 | 99% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 10.597 | 10.597 | 0.000 | 99% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 10.101 | 10.101 | 0.000 | 99% |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 9.442 | 9.442 | 0.000 | 99% |
| 4.A.1 Forest land remaining forest land - wildfires | $CH_4$ | 9.198 | 9.198 | 0.000 | 99% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CH_4$ | 8.745 | 8.745 | 0.000 | 99% |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | 8.696 | 8.696 | 0.000 | 99% |
| 2.G.1. Electrical equipment | SF6 | 8.578 | 8.578 | 0.000 | 99% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – dead organic | $CO_2$ | -8.557 | 8.557 | 0.000 | 99% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| matter | | | | | |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 8.434 | 8.434 | 0.000 | 99% |
| 2.D.1 Lubricant Use | $CO_2$ | 8.298 | 8.298 | 0.000 | 99% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – living biomass | $CO_2$ | -8.288 | 8.288 | 0.000 | 100% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 7.840 | 7.840 | 0.000 | 100% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 5.647 | 5.647 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 5.564 | 5.564 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 5.487 | 5.487 | 0.000 | 100% |
| 4.B.2 Settlements converted to cropland, mineral soils | $CO_2$ | 5.310 | 5.310 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 5.263 | 5.263 | 0.000 | 100% |
| 2.D.2 Paraffin wax use | $CO_2$ | 4.912 | 4.912 | 0.000 | 100% |
| 4.B.2 Land converted to cropland, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 4.883 | 4.883 | 0.000 | 100% |
| 3.H. Urea Application | $CO_2$ | 4.726 | 4.726 | 0.000 | 100% |
| 2.F.4. Aerosols | HFCs | 4.698 | 4.698 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 4.607 | 4.607 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 4.555 | 4.555 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.381 | 4.381 | 0.000 | 100% |
| 4.E.2 Settlements remaining Settlements, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 4.083 | 4.083 | 0.000 | 100% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 3.983 | 3.983 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 3.907 | 3.907 | 0.000 | 100% |
| 4.B.2 Wetlands converted to cropland, organic soil | $CO_2$ | 3.824 | 3.824 | 0.000 | 100% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $N_2O$ | 3.793 | 3.793 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 3.134 | 3.134 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 2.934 | 2.934 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 2.625 | 2.625 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 2.456 | 2.456 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 2.270 | 2.270 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 2.270 | 2.270 | 0.000 | 100% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 2.221 | 2.221 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 2.207 | 2.207 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 2.126 | 2.126 | 0.000 | 100% |
| 2.G.3. $N_2O$ from product uses | $N_2O$ | 2.014 | 2.014 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 1.520 | 1.520 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 1.509 | 1.509 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 1.490 | 1.490 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.357 | 1.357 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $CO_2$ | 1.331 | 1.331 | 0.000 | 100% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – dead organic matter | $CO_2$ | -1.291 | 1.291 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 1.276 | 1.276 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 1.136 | 1.136 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 1.122 | 1.122 | 0.000 | 100% |
| 4.A.1 Forest land remaining forest land - wildfires | $N_2O$ | 1.078 | 1.078 | 0.000 | 100% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $N_2O$ | 1.025 | 1.025 | 0.000 | 100% |
| 2.F.2 Foam blowing agents | HFCs | 0.961 | 0.961 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.949 | 0.949 | 0.000 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.943 | 0.943 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CH_4$ | 0.937 | 0.937 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 0.865 | 0.865 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.864 | 0.864 | 0.000 | 100% |
| 2.D.3.d Urea Use | $CO_2$ | 0.817 | 0.817 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 0.726 | 0.726 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 0.705 | 0.705 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $N_2O$ | 0.663 | 0.663 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 0.650 | 0.650 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $CH_4$ | 0.609 | 0.609 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 0.591 | 0.591 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.563 | 0.563 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.561 | 0.561 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.557 | 0.557 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.550 | 0.550 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.532 | 0.532 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0.470 | 0.470 | 0.000 | 100% |
| 2.A.2. Lime Production | $CO_2$ | 0.460 | 0.460 | 0.000 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.439 | 0.439 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 0.431 | 0.431 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 0.398 | 0.398 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 0.370 | 0.370 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.351 | 0.351 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0.349 | 0.349 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.347 | 0.347 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.345 | 0.345 | 0.000 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0.335 | 0.335 | 0.000 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.300 | 0.300 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0.296 | 0.296 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.280 | 0.280 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 0.252 | 0.252 | 0.000 | 100% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 0.237 | 0.237 | 0.000 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0.211 | 0.211 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 0.182 | 0.182 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 0.180 | 0.180 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 0.174 | 0.174 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.131 | 0.131 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 0.127 | 0.127 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.127 | 0.127 | 0.000 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 0.116 | 0.116 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 0.102 | 0.102 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 0.078 | 0.078 | 0.000 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0.076 | 0.076 | 0.000 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.054 | 0.054 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.052 | 0.052 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.051 | 0.051 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.050 | 0.050 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.049 | 0.049 | 0.000 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.049 | 0.049 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 0.044 | 0.044 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.043 | 0.043 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.042 | 0.042 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.040 | 0.040 | 0.000 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0.035 | 0.035 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0.035 | 0.035 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.034 | 0.034 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.033 | 0.033 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.031 | 0.031 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.030 | 0.030 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.029 | 0.029 | 0.000 | 100% |
| 2.F.3. Fire Protection | HFCs | 0.028 | 0.028 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.026 | 0.026 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.025 | 0.025 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Biomass | $CH_4$ | 0.023 | 0.023 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0.022 | 0.022 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.021 | 0.021 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.021 | 0.021 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.021 | 0.021 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.020 | 0.020 | 0.000 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0.019 | 0.019 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.017 | 0.017 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.015 | 0.015 | 0.000 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.011 | 0.011 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.011 | 0.011 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.011 | 0.011 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 0.010 | 0.010 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.009 | 0.009 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.008 | 0.008 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.007 | 0.007 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.006 | 0.006 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $N_2O$ | 0.006 | 0.006 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 0.006 | 0.006 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0.005 | 0.005 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.005 | 0.005 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.005 | 0.005 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.004 | 0.004 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0.004 | 0.004 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0.002 | 0.002 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| TOTAL | | 15573.52 | 30581.938 | | |

### A.1.6 Spreadsheet for the Approach 1 analysis for 2014 – level assessment without LULUCF

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 1880.266 | 1880.266 | 0.166 | 17% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 1575.699 | 1575.699 | 0.139 | 30% |
| 3.D.1. Direct $N_2O$ emissions from managed soils | $N_2O$ | 1429.498 | 1429.498 | 0.126 | 43% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 828.043 | 828.043 | 0.073 | 50% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 613.358 | 613.358 | 0.054 | 56% |
| 2.A.1. Cement Production | $CO_2$ | 555.776 | 555.776 | 0.049 | 61% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 320.575 | 320.575 | 0.028 | 63% |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 301.024 | 301.024 | 0.027 | 66% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 238.797 | 238.797 | 0.021 | 68% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 230.712 | 230.712 | 0.020 | 70% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 227.802 | 227.802 | 0.020 | 72% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 213.786 | 213.786 | 0.019 | 74% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Level assessment | Cumulative total of Level assessment |
|---|---|---|---|---|---|
| 2.F.1. Refrigeration and air conditioning | HFCs | 206.377 | 206.377 | 0.018 | 76% |
| 3.D.2 Indirect $N_2O$ Emissions from managed soils | $N_2O$ | 196.044 | 196.044 | 0.017 | 78% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 165.243 | 165.243 | 0.015 | 79% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 157.132 | 157.132 | 0.014 | 81% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 155.562 | 155.562 | 0.014 | 82% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 138.525 | 138.525 | 0.012 | 83% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 118.628 | 118.628 | 0.010 | 84% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 109.507 | 109.507 | 0.010 | 85% |
| 1.B.2.b Natural Gas | $CH_4$ | 109.190 | 109.190 | 0.010 | 86% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | 107.569 | 107.569 | 0.009 | 87% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 104.814 | 104.814 | 0.009 | 88% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 101.654 | 101.654 | 0.009 | 89% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 93.815 | 93.815 | 0.008 | 90% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 91.048 | 91.048 | 0.008 | 90% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 73.413 | 73.413 | 0.006 | 91% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 70.595 | 70.595 | 0.006 | 92% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 55.182 | 55.182 | 0.005 | 92% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 50.233 | 50.233 | 0.004 | 93% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 45.035 | 45.035 | 0.004 | 93% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 42.947 | 42.947 | 0.004 | 93% |
| 3.B.5 Indirect $N_2O$ emissions from Manure Management | $N_2O$ | 41.938 | 41.938 | 0.004 | 94% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 38.502 | 38.502 | 0.003 | 94% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 34.973 | 34.973 | 0.003 | 94% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 33.544 | 33.544 | 0.003 | 95% |
| 2.D.3. Solvent Use | $CO_2$ | 32.197 | 32.197 | 0.003 | 95% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 26.178 | 26.178 | 0.002 | 95% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 26.126 | 26.126 | 0.002 | 95% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 24.624 | 24.624 | 0.002 | 96% |
| 5.B.1. Composting | $CH_4$ | 22.465 | 22.465 | 0.002 | 96% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 21.164 | 21.164 | 0.002 | 96% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 20.646 | 20.646 | 0.002 | 96% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 20.350 | 20.350 | 0.002 | 96% |

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|---|---|---|---|---|---|
| 3.G. Liming | $CO_2$ | 19.686 | 19.686 | 0.002 | 97% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 19.447 | 19.447 | 0.002 | 97% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 18.500 | 18.500 | 0.002 | 97% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 17.427 | 17.427 | 0.002 | 97% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 17.146 | 17.146 | 0.002 | 97% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 16.555 | 16.555 | 0.001 | 97% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 16.537 | 16.537 | 0.001 | 98% |
| 5.B.1. Composting | $N_2O$ | 16.067 | 16.067 | 0.001 | 98% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 13.386 | 13.386 | 0.001 | 98% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 13.103 | 13.103 | 0.001 | 98% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 13.022 | 13.022 | 0.001 | 98% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 12.580 | 12.580 | 0.001 | 98% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 11.522 | 11.522 | 0.001 | 98% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 10.965 | 10.965 | 0.001 | 98% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 10.833 | 10.833 | 0.001 | 98% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 10.597 | 10.597 | 0.001 | 99% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 10.101 | 10.101 | 0.001 | 99% |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 9.442 | 9.442 | 0.001 | 99% |
| 2.G.1. Electrical equipment | SF6 | 8.578 | 8.578 | 0.001 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 8.434 | 8.434 | 0.001 | 99% |
| 2.D.1 Lubricant Use | $CO_2$ | 8.298 | 8.298 | 0.001 | 99% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 7.840 | 7.840 | 0.001 | 99% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 5.647 | 5.647 | 0.000 | 99% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 5.564 | 5.564 | 0.000 | 99% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 5.487 | 5.487 | 0.000 | 99% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 5.263 | 5.263 | 0.000 | 99% |
| 2.D.2 Paraffin wax use | $CO_2$ | 4.912 | 4.912 | 0.000 | 99% |
| 3.H. Urea Application | $CO_2$ | 4.726 | 4.726 | 0.000 | 99% |
| 2.F.4. Aerosols | HFCs | 4.698 | 4.698 | 0.000 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 4.607 | 4.607 | 0.000 | 99% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 4.555 | 4.555 | 0.000 | 99% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.381 | 4.381 | 0.000 | 99% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 3.983 | 3.983 | 0.000 | 99% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 3.907 | 3.907 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 3.134 | 3.134 | 0.000 | 100% |

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|---|---|---|---|---|---|
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 2.934 | 2.934 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 2.625 | 2.625 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 2.456 | 2.456 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 2.270 | 2.270 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 2.270 | 2.270 | 0.000 | 100% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 2.221 | 2.221 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 2.207 | 2.207 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 2.126 | 2.126 | 0.000 | 100% |
| 2.G.3. $N_2O$ from product uses | $N_2O$ | 2.014 | 2.014 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 1.520 | 1.520 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 1.509 | 1.509 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 1.490 | 1.490 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.357 | 1.357 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $CO_2$ | 1.331 | 1.331 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 1.276 | 1.276 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 1.136 | 1.136 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 1.122 | 1.122 | 0.000 | 100% |
| 2.F.2 Foam blowing agents | HFCs | 0.961 | 0.961 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.949 | 0.949 | 0.000 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.943 | 0.943 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CH_4$ | 0.937 | 0.937 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 0.865 | 0.865 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.864 | 0.864 | 0.000 | 100% |
| 2.D.3.d Urea Use | $CO_2$ | 0.817 | 0.817 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 0.726 | 0.726 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 0.705 | 0.705 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 0.650 | 0.650 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 0.591 | 0.591 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.563 | 0.563 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.561 | 0.561 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.557 | 0.557 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous | $CH_4$ | 0.550 | 0.550 | 0.000 | 100% |

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|---|---|---|---|---|---|
| Fuels | | | | | |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.532 | 0.532 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0.470 | 0.470 | 0.000 | 100% |
| 2.A.2. Lime Production | $CO_2$ | 0.460 | 0.460 | 0.000 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.439 | 0.439 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 0.431 | 0.431 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 0.398 | 0.398 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 0.370 | 0.370 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.351 | 0.351 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0.349 | 0.349 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.347 | 0.347 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.345 | 0.345 | 0.000 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0.335 | 0.335 | 0.000 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.300 | 0.300 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0.296 | 0.296 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.280 | 0.280 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 0.252 | 0.252 | 0.000 | 100% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 0.237 | 0.237 | 0.000 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0.211 | 0.211 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 0.182 | 0.182 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 0.180 | 0.180 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 0.174 | 0.174 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.131 | 0.131 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 0.127 | 0.127 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.127 | 0.127 | 0.000 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 0.116 | 0.116 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 0.102 | 0.102 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 0.078 | 0.078 | 0.000 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0.076 | 0.076 | 0.000 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.054 | 0.054 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.052 | 0.052 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and | $N_2O$ | 0.051 | 0.051 | 0.000 | 100% |

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|---|---|---|---|---|---|
| Other Energy Industries - Liquid Fuels | | | | | |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.050 | 0.050 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.049 | 0.049 | 0.000 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.049 | 0.049 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 0.044 | 0.044 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.043 | 0.043 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.042 | 0.042 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.040 | 0.040 | 0.000 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0.035 | 0.035 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0.035 | 0.035 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.034 | 0.034 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.033 | 0.033 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.031 | 0.031 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.030 | 0.030 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.029 | 0.029 | 0.000 | 100% |
| 2.F.3. Fire Protection | HFCs | 0.028 | 0.028 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.026 | 0.026 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.025 | 0.025 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Biomass | $CH_4$ | 0.023 | 0.023 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0.022 | 0.022 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.021 | 0.021 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.021 | 0.021 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.021 | 0.021 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.020 | 0.020 | 0.000 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0.019 | 0.019 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.017 | 0.017 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.015 | 0.015 | 0.000 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.011 | 0.011 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.011 | 0.011 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.011 | 0.011 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 0.010 | 0.010 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.009 | 0.009 | 0.000 | 100% |

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|---|---|---|---|---|---|
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.008 | 0.008 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.007 | 0.007 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.006 | 0.006 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $N_2O$ | 0.006 | 0.006 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 0.006 | 0.006 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0.005 | 0.005 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.005 | 0.005 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.005 | 0.005 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.004 | 0.004 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0.004 | 0.004 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.003 | 0.003 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0.002 | 0.002 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0.001 | 0.001 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.000 | 0.000 | 0.000 | 100% |

| **IPCC category/Group** | **Gas** | **2014 emissions or removals (kt $CO_2$ eq)** | **Absolute value of 2014 emissions (kt $CO_2$ eq)** | **Level assessment** | **Cumulative total of Level assessment** |
|---|---|---|---|---|---|
| TOTAL | | 11353.38 | 11353.38 | 1.000 | |

### A.1.7 Spreadsheet for the Approach 2 analysis for 2014 – level assessment with LULUCF

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.E.2 Land converted to Settlements – Carbon stock change – living biomass | $CO_2$ | 480.918 | 480.918 | 20% | 295% | 2.953 | 0.016 | 0.046 | 0.139 | 14% |
| 4.A.1 Forest Land remaining Forest Land – Drained organic soil | $CO_2$ | 4583.281 | 4583.281 | 5% | 25% | 0.256 | 0.150 | 0.038 | 0.114 | 25% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $N_2O$ | 638.801 | 638.801 | 6% | 119% | 1.193 | 0.021 | 0.025 | 0.074 | 33% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – living biomass | $CO_2$ | -165.232 | 165.232 | 6% | 435% | 4.352 | 0.005 | 0.024 | 0.070 | 40% |
| 3.D.1. Direct $N_2O$ emissions from managed soils | $N_2O$ | 1429.498 | 1429.498 | 2% | 50% | 0.500 | 0.047 | 0.023 | 0.070 | 47% |
| 4.B.1 Cropland remaining Cropland – Drained organic soil | $CO_2$ | 2598.777 | 2598.777 | 13% | 18% | 0.227 | 0.085 | 0.019 | 0.058 | 53% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – living biomass | $CO_2$ | -108.186 | 108.186 | 9% | 389% | 3.896 | 0.004 | 0.014 | 0.041 | 57% |
| 4.C.2 Land converted to Grassland –Mineral soil | $CO_2$ | -495.257 | 495.257 | 10% | 61% | 0.620 | 0.016 | 0.010 | 0.030 | 60% |
| 4. G. Harvested wood products | $CO_2$ | -1817.580 | 1817.580 | 15% | 0% | 0.150 | 0.059 | 0.009 | 0.027 | 62% |
| 4.C.1 Grassland remaining Grassland – Drained organic soil | $CO_2$ | 684.007 | 684.007 | 26% | 19% | 0.319 | 0.022 | 0.007 | 0.021 | 64% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CO_2$ | 899.741 | 899.741 | 24% | | 0.242 | 0.029 | 0.007 | 0.021 | 67% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood | $CO_2$ | -3792.439 | 3792.439 | 2% | 5% | 0.050 | 0.124 | 0.006 | 0.018 | 68% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 149.853 | 149.853 | 5% | 119% | 1.186 | 0.005 | 0.006 | 0.017 | 70% |
| 4.A.2 Land converted to Forest Land – Carbon stock change, grassland converted to forest land | $CO_2$ | -341.174 | 341.174 | 8% | 50% | 0.504 | 0.011 | 0.006 | 0.017 | 72% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change –organic soils | $CO_2$ | 277.200 | 277.200 | 24% | 55% | 0.604 | 0.009 | 0.005 | 0.016 | 74% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 828.043 | 828.043 | 2% | 20% | 0.201 | 0.027 | 0.005 | 0.016 | 75% |
| 4.C.2 Land converted to Grassland – Drained organic soil | $CO_2$ | 275.392 | 275.392 | 55% | 19% | 0.583 | 0.009 | 0.005 | 0.016 | 77% |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 301.024 | 301.024 | 7% | 52% | 0.525 | 0.010 | 0.005 | 0.015 | 78% |
| 2.F.1. Refrigeration and air conditioning | HFCs | 206.377 | 206.377 | 50% | 50% | 0.707 | 0.007 | 0.005 | 0.014 | 80% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 227.802 | 227.802 | 7% | 52% | 0.525 | 0.007 | 0.004 | 0.012 | 81% |
| 4.B.2 Land converted to Cropland – Drained organic soil | $CO_2$ | 89.507 | 89.507 | 114% | 18% | 1.153 | 0.003 | 0.003 | 0.010 | 82% |
| 3.D.2 Indirect $N_2O$ Emissions from managed soils | $N_2O$ | 196.044 | 196.044 | 2% | 50% | 0.500 | 0.006 | 0.003 | 0.010 | 83% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 138.525 | 138.525 | 64% | 30% | 0.707 | 0.005 | 0.003 | 0.010 | 84% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.B. Cropland remaining cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 119.045 | 119.045 | 13% | 71% | 0.722 | 0.004 | 0.003 | 0.008 | 85% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 1575.699 | 1575.699 | 2% | 5% | 0.054 | 0.052 | 0.003 | 0.008 | 85% |
| 4.E.2 Land converted to Settlements – Organic soils | $CO_2$ | 166.176 | 166.176 | 47% | 18% | 0.505 | 0.005 | 0.003 | 0.008 | 86% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CO_2$ | 88.884 | 88.884 | 92% | 6% | 0.922 | 0.003 | 0.003 | 0.008 | 87% |
| 4.E.2 Land converted to Settlements – Mineral soils | $CO_2$ | 107.292 | 107.292 | 22% | 60% | 0.639 | 0.004 | 0.002 | 0.007 | 88% |
| 2.A.1. Cement Production | $CO_2$ | 555.776 | 555.776 | 10% | 5% | 0.112 | 0.018 | 0.002 | 0.006 | 88% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 109.507 | 109.507 | 45% | 30% | 0.541 | 0.004 | 0.002 | 0.006 | 89% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – living biomass | $CO_2$ | -8.288 | 8.288 | 3% | 701% | 7.007 | 0.000 | 0.002 | 0.006 | 89% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CO_2$ | 22.068 | 22.068 | 5% | 242% | 2.421 | 0.001 | 0.002 | 0.005 | 90% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 1880.266 | 1880.266 | 2% | 2% | 0.028 | 0.061 | 0.002 | 0.005 | 91% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – living biomass | $CO_2$ | -42.877 | 42.877 | 5% | 122% | 1.222 | 0.001 | 0.002 | 0.005 | 91% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.C. Grassland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 72.895 | 72.895 | 24% | 58% | 0.629 | 0.002 | 0.002 | 0.004 | 91% |
| 4.B.2 Land converted to Cropland –Mineral soil | $CO_2$ | 48.750 | 48.750 | 64% | 61% | 0.889 | 0.002 | 0.001 | 0.004 | 92% |
| 4.E.2 Land converted to Settlements – Carbon stock change – dead organic matter | $CO_2$ | 197.497 | 197.497 | 20% | | 0.196 | 0.006 | 0.001 | 0.004 | 92% |
| 4.B.2 Land converted to Cropland – Carbon stock change, forest land converted to cropland | $CO_2$ | 21.176 | 21.176 | 53% | 161% | 1.693 | 0.001 | 0.001 | 0.004 | 93% |
| 1.B.2.b Natural Gas | $CH_4$ | 109.190 | 109.190 | 32% | 0% | 0.322 | 0.004 | 0.001 | 0.003 | 93% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 320.575 | 320.575 | 2% | 11% | 0.109 | 0.010 | 0.001 | 0.003 | 93% |
| 4.A.2 Land converted to Forest Land – grassland converted to forest land, Drained organic soil | $CO_2$ | 61.248 | 61.248 | 44% | 25% | 0.502 | 0.002 | 0.001 | 0.003 | 94% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 55.182 | 55.182 | 2% | 50% | 0.500 | 0.002 | 0.001 | 0.003 | 94% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 118.628 | 118.628 | 2% | 20% | 0.201 | 0.004 | 0.001 | 0.002 | 94% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 16.537 | 16.537 | 140% | 30% | 1.432 | 0.001 | 0.001 | 0.002 | 94% |
| 5.B.1. Composting | $CH_4$ | 22.465 | 22.465 | 29% | 100% | 1.041 | 0.001 | 0.001 | 0.002 | 95% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 70.595 | 70.595 | 25% | 20% | 0.320 | 0.002 | 0.001 | 0.002 | 95% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CH_4$ | 28.534 | 28.534 | 24% | 71% | 0.751 | 0.001 | 0.001 | 0.002 | 95% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 34.973 | 34.973 | 5% | 50% | 0.502 | 0.001 | 0.001 | 0.002 | 95% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 613.358 | 613.358 | 2% | 2% | 0.028 | 0.020 | 0.001 | 0.002 | 95% |
| 4.E.2 Lands converted to settlements, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 40.479 | 40.479 | 20% | 38% | 0.425 | 0.001 | 0.001 | 0.002 | 96% |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass | $CO_2$ | -529.092 | 529.092 | 2% | 3% | 0.032 | 0.017 | 0.001 | 0.002 | 96% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 33.544 | 33.544 | 2% | 50% | 0.500 | 0.001 | 0.001 | 0.002 | 96% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 157.132 | 157.132 | 2% | 10% | 0.102 | 0.005 | 0.001 | 0.002 | 96% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 155.562 | 155.562 | 2% | 10% | 0.102 | 0.005 | 0.001 | 0.002 | 96% |
| 5.B.1. Composting | $N_2O$ | 16.067 | 16.067 | 29% | 90% | 0.946 | 0.001 | 0.000 | 0.001 | 96% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 101.654 | 101.654 | 10% | 10% | 0.141 | 0.003 | 0.000 | 0.001 | 96% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 42.947 | 42.947 | 25% | 20% | 0.320 | 0.001 | 0.000 | 0.001 | 97% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 238.797 | 238.797 | 2% | 5% | 0.054 | 0.008 | 0.000 | 0.001 | 97% |
| 3.B.5 Indirect $N_2O$ emissions from Manure Management | $N_2O$ | 41.938 | 41.938 | 2% | 30% | 0.301 | 0.001 | 0.000 | 0.001 | 97% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 230.712 | 230.712 | 2% | 5% | 0.054 | 0.008 | 0.000 | 0.001 | 97% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 24.624 | 24.624 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.001 | 97% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 213.786 | 213.786 | 2% | 5% | 0.054 | 0.007 | 0.000 | 0.001 | 97% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 104.814 | 104.814 | 2% | 10% | 0.102 | 0.003 | 0.000 | 0.001 | 97% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 50.233 | 50.233 | 2% | 20% | 0.201 | 0.002 | 0.000 | 0.001 | 97% |
| 3.G. Liming | $CO_2$ | 19.686 | 19.686 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.001 | 98% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 19.447 | 19.447 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.001 | 98% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 18.500 | 18.500 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.001 | 98% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 165.243 | 165.243 | 2% | 5% | 0.054 | 0.005 | 0.000 | 0.001 | 98% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 17.427 | 17.427 | 5% | 50% | 0.502 | 0.001 | 0.000 | 0.001 | 98% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CH_4$ | 8.745 | 8.745 | 92% | 36% | 0.988 | 0.000 | 0.000 | 0.001 | 98% |
| 4.B.2 Land converted to cropland, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 4.883 | 4.883 | 64% | 151% | 1.639 | 0.000 | 0.000 | 0.001 | 98% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 38.502 | 38.502 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.001 | 98% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 13.386 | 13.386 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.001 | 98% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, dead wood | $CO_2$ | -83.797 | 83.797 | 8% | | 0.080 | 0.003 | 0.000 | 0.001 | 98% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 20.646 | 20.646 | 25% | 20% | 0.320 | 0.001 | 0.000 | 0.001 | 98% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 13.022 | 13.022 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 98% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.D.3. Solvent Use | $CO_2$ | 32.197 | 32.197 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.001 | 98% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, litter | $CO_2$ | -71.844 | 71.844 | 8% | | 0.080 | 0.002 | 0.000 | 0.001 | 98% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 10.965 | 10.965 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.001 | 99% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 10.833 | 10.833 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 93.815 | 93.815 | 2% | 5% | 0.054 | 0.003 | 0.000 | 0.000 | 99% |
| 2.D.2 Paraffin wax use | $CO_2$ | 4.912 | 4.912 | 2% | 100% | 1.000 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 91.048 | 91.048 | 2% | 5% | 0.054 | 0.003 | 0.000 | 0.000 | 99% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.381 | 4.381 | 43% | 100% | 1.089 | 0.000 | 0.000 | 0.000 | 99% |
| 4.A.1 Forest land remaining forest land - wildfires | $CH_4$ | 9.198 | 9.198 | 37% | 36% | 0.516 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 9.442 | 9.442 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 4.B.2 Settlements converted to cropland, mineral soils | $CO_2$ | 5.310 | 5.310 | 64% | 60% | 0.881 | 0.000 | 0.000 | 0.000 | 99% |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | 8.696 | 8.696 | 53% | | 0.534 | 0.000 | 0.000 | 0.000 | 99% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 11.522 | 11.522 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 99% |
| 4.B.2 Wetlands converted to cropland, organic soil | $CO_2$ | 3.824 | 3.824 | 114% | 18% | 1.153 | 0.000 | 0.000 | 0.000 | 99% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $N_2O$ | 3.793 | 3.793 | 24% | 112% | 1.146 | 0.000 | 0.000 | 0.000 | 99% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 8.434 | 8.434 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 99% |
| 2.D.1 Lubricant Use | $CO_2$ | 8.298 | 8.298 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 73.413 | 73.413 | 2% | 5% | 0.054 | 0.002 | 0.000 | 0.000 | 99% |
| 4.E.1 Settlements remaining Settlements – Drained organic soils | $CO_2$ | 19.430 | 19.430 | 9% | 18% | 0.203 | 0.001 | 0.000 | 0.000 | 99% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 10.597 | 10.597 | 10% | 30% | 0.316 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 16.555 | 16.555 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.000 | 99% |
| 2.F.4. Aerosols | HFCs | 4.698 | 4.698 | 50% | 50% | 0.707 | 0.000 | 0.000 | 0.000 | 99% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 7.840 | 7.840 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | 107.569 | 107.569 | 2% | 2% | 0.028 | 0.004 | 0.000 | 0.000 | 99% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 26.178 | 26.178 | 2% | 11% | 0.111 | 0.001 | 0.000 | 0.000 | 99% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 5.564 | 5.564 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 99% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 13.103 | 13.103 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 99% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 26.126 | 26.126 | 10% | 0% | 0.100 | 0.001 | 0.000 | 0.000 | 100% |
| 2.G.1. Electrical equipment | SF6 | 8.578 | 8.578 | 2% | 30% | 0.301 | 0.000 | 0.000 | 0.000 | 100% |
| 3.H. Urea Application | $CO_2$ | 4.726 | 4.726 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 45.035 | 45.035 | 2% | 5% | 0.054 | 0.001 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 4.607 | 4.607 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 21.164 | 21.164 | 2% | 10% | 0.102 | 0.001 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 20.350 | 20.350 | 2% | 10% | 0.102 | 0.001 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 3.983 | 3.983 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 5.647 | 5.647 | 25% | 20% | 0.320 | 0.000 | 0.000 | 0.000 | 100% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – dead organic matter | $CO_2$ | -29.466 | 29.466 | 6% | | 0.059 | 0.001 | 0.000 | 0.000 | 100% |
| 4.E.2 Settlements remaining Settlements, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 4.083 | 4.083 | 9% | 38% | 0.387 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 2.934 | 2.934 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 2.625 | 2.625 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 2.270 | 2.270 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 5.487 | 5.487 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 10.101 | 10.101 | 2% | 10% | 0.102 | 0.000 | 0.000 | 0.000 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 4.A.1 Forest land remaining forest land - Controlled burning | $N_2O$ | 1.025 | 1.025 | 92% | | 0.920 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 17.146 | 17.146 | 2% | 5% | 0.054 | 0.001 | 0.000 | 0.000 | 100% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – dead organic matter | $CO_2$ | -10.612 | 10.612 | 9% | | 0.087 | 0.000 | 0.000 | 0.000 | 100% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 2.221 | 2.221 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.943 | 0.943 | 2% | 86% | 0.860 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 1.520 | 1.520 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 1.509 | 1.509 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 1.490 | 1.490 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.F.2 Foam blowing agents | HFCs | 0.961 | 0.961 | 50% | 50% | 0.707 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 12.580 | 12.580 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 2.207 | 2.207 | 2% | 30% | 0.301 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 1.276 | 1.276 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 4.555 | 4.555 | 10% | 5% | 0.112 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.949 | 0.949 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CH_4$ | 0.937 | 0.937 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 2.270 | 2.270 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 0.865 | 0.865 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.864 | 0.864 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 2.126 | 2.126 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – dead organic matter | $CO_2$ | -8.557 | 8.557 | 5% | | 0.050 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.357 | 1.357 | 2% | 30% | 0.301 | 0.000 | 0.000 | 0.000 | 100% |
| 4.A.1 Forest land remaining forest land - wildfires | $N_2O$ | 1.078 | 1.078 | 37% | | 0.370 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 0.726 | 0.726 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.563 | 0.563 | 43% | 40% | 0.587 | 0.000 | 0.000 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $N_2O$ | 0.663 | 0.663 | 10% | 48% | 0.490 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 0.650 | 0.650 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 0.591 | 0.591 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 5.263 | 5.263 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.561 | 0.561 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.557 | 0.557 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.550 | 0.550 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.532 | 0.532 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 2.456 | 2.456 | 2% | 10% | 0.102 | 0.000 | 0.000 | 0.000 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $CH_4$ | 0.609 | 0.609 | 10% | 39% | 0.403 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0.470 | 0.470 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 2.A.2. Lime Production | $CO_2$ | 0.460 | 0.460 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 0.431 | 0.431 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 3.907 | 3.907 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 0.370 | 0.370 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.d Urea Use | $CO_2$ | 0.817 | 0.817 | 20% | 10% | 0.224 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.351 | 0.351 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0.349 | 0.349 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.345 | 0.345 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.439 | 0.439 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 3.134 | 3.134 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0.335 | 0.335 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.300 | 0.300 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

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| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0.296 | 0.296 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $CO_2$ | 1.331 | 1.331 | 2% | 10% | 0.102 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 0.252 | 0.252 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 1.136 | 1.136 | 2% | 11% | 0.111 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 1.122 | 1.122 | 2% | 11% | 0.111 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 0.237 | 0.237 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0.211 | 0.211 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 0.182 | 0.182 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 0.180 | 0.180 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 0.174 | 0.174 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.347 | 0.347 | 20% | 5% | 0.206 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.131 | 0.131 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 0.127 | 0.127 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.127 | 0.127 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.G.3. $N_2O$ from product uses | $N_2O$ | 2.014 | 2.014 | 2% | 2% | 0.028 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 0.102 | 0.102 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 0.116 | 0.116 | 23% | 30% | 0.378 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 0.398 | 0.398 | 2% | 10% | 0.102 | 0.000 | 0.000 | 0.000 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 0.078 | 0.078 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0.076 | 0.076 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 0.705 | 0.705 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.054 | 0.054 | 20% | 60% | 0.632 | 0.000 | 0.000 | 0.000 | 100% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – dead organic matter | $CO_2$ | -1.291 | 1.291 | 3% | | 0.026 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.049 | 0.049 | 20% | 60% | 0.632 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.052 | 0.052 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.051 | 0.051 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.050 | 0.050 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.049 | 0.049 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 0.044 | 0.044 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.043 | 0.043 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.042 | 0.042 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.040 | 0.040 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.F.3. Fire Protection | HFCs | 0.028 | 0.028 | 50% | 50% | 0.707 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0.035 | 0.035 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0.035 | 0.035 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.034 | 0.034 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.033 | 0.033 | 10% | 50% | 0.510 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.031 | 0.031 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.030 | 0.030 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.280 | 0.280 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.029 | 0.029 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.026 | 0.026 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.025 | 0.025 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Biomass | $CH_4$ | 0.023 | 0.023 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0.022 | 0.022 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.021 | 0.021 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.021 | 0.021 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.021 | 0.021 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.020 | 0.020 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0.019 | 0.019 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.017 | 0.017 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.015 | 0.015 | 10% | 50% | 0.510 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.011 | 0.011 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.011 | 0.011 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.009 | 0.009 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.008 | 0.008 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.011 | 0.011 | 32% | 0% | 0.322 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.007 | 0.007 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.006 | 0.006 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $N_2O$ | 0.006 | 0.006 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 0.006 | 0.006 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 0.010 | 0.010 | 5% | 25% | 0.255 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0.005 | 0.005 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.005 | 0.005 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.005 | 0.005 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.004 | 0.004 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0.004 | 0.004 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |

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| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.003 | 0.003 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.003 | 0.003 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $CH_4$ | 0.002 | 0.002 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.003 | 0.003 | 10% | 0% | 0.100 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000 | 0.000 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.000 | 0.000 | 10% | 25% | 0.269 | 0.000 | 0.000 | 0.000 | 100% |
| TOTAL | | 15573.52 | 30581.938 | | | 162.446 | 1.000 | 0.335 | 1.000 | |

### A.1.8 Spreadsheet for the Approach 2 analysis for 2014 – level assessment without LULUCF

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.D.1. Direct $N_2O$ emissions from managed soils | $N_2O$ | 1429.498 | 1429.498 | 2% | 50% | 0.500 | 0.126 | 0.063 | 0.303 | 30% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 828.043 | 828.043 | 2% | 20% | 0.201 | 0.073 | 0.015 | 0.070 | 37% |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 301.024 | 301.024 | 7% | 52% | 0.525 | 0.027 | 0.014 | 0.067 | 44% |
| 2.F.1. Refrigeration and air conditioning | HFCs | 206.377 | 206.377 | 50% | 50% | 0.707 | 0.018 | 0.013 | 0.062 | 50% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 227.802 | 227.802 | 7% | 52% | 0.525 | 0.020 | 0.011 | 0.051 | 55% |
| 3.D.2 Indirect $N_2O$ Emissions from managed soils | $N_2O$ | 196.044 | 196.044 | 2% | 50% | 0.500 | 0.017 | 0.009 | 0.042 | 59% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 138.525 | 138.525 | 64% | 30% | 0.707 | 0.012 | 0.009 | 0.041 | 64% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 1575.699 | 1575.699 | 2% | 5% | 0.054 | 0.139 | 0.007 | 0.036 | 67% |
| 2.A.1. Cement Production | $CO_2$ | 555.776 | 555.776 | 10% | 5% | 0.112 | 0.049 | 0.005 | 0.026 | 70% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 109.507 | 109.507 | 45% | 30% | 0.541 | 0.010 | 0.005 | 0.025 | 72% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 1880.266 | 1880.266 | 2% | 2% | 0.028 | 0.166 | 0.005 | 0.022 | 74% |
| 1.B.2.b Natural Gas | $CH_4$ | 109.190 | 109.190 | 32% | 0% | 0.322 | 0.010 | 0.003 | 0.015 | 76% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 320.575 | 320.575 | 2% | 11% | 0.109 | 0.028 | 0.003 | 0.015 | 77% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 55.182 | 55.182 | 2% | 50% | 0.500 | 0.005 | 0.002 | 0.012 | 79% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 118.628 | 118.628 | 2% | 20% | 0.201 | 0.010 | 0.002 | 0.010 | 80% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 16.537 | 16.537 | 140% | 30% | 1.432 | 0.001 | 0.002 | 0.010 | 81% |
| 5.B.1. Composting | $CH_4$ | 22.465 | 22.465 | 29% | 100% | 1.041 | 0.002 | 0.002 | 0.010 | 82% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 70.595 | 70.595 | 25% | 20% | 0.320 | 0.006 | 0.002 | 0.010 | 83% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 34.973 | 34.973 | 5% | 50% | 0.502 | 0.003 | 0.002 | 0.007 | 83% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 613.358 | 613.358 | 2% | 2% | 0.028 | 0.054 | 0.002 | 0.007 | 84% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 33.544 | 33.544 | 2% | 50% | 0.500 | 0.003 | 0.001 | 0.007 | 85% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 157.132 | 157.132 | 2% | 10% | 0.102 | 0.014 | 0.001 | 0.007 | 85% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 155.562 | 155.562 | 2% | 10% | 0.102 | 0.014 | 0.001 | 0.007 | 86% |
| 5.B.1. Composting | $N_2O$ | 16.067 | 16.067 | 29% | 90% | 0.946 | 0.001 | 0.001 | 0.006 | 87% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 101.654 | 101.654 | 10% | 10% | 0.141 | 0.009 | 0.001 | 0.006 | 87% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 42.947 | 42.947 | 25% | 20% | 0.320 | 0.004 | 0.001 | 0.006 | 88% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 238.797 | 238.797 | 2% | 5% | 0.054 | 0.021 | 0.001 | 0.005 | 88% |
| 3.B.5 Indirect $N_2O$ emissions from Manure Management | $N_2O$ | 41.938 | 41.938 | 2% | 30% | 0.301 | 0.004 | 0.001 | 0.005 | 89% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 230.712 | 230.712 | 2% | 5% | 0.054 | 0.020 | 0.001 | 0.005 | 90% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 24.624 | 24.624 | 2% | 50% | 0.500 | 0.002 | 0.001 | 0.005 | 90% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 213.786 | 213.786 | 2% | 5% | 0.054 | 0.019 | 0.001 | 0.005 | 91% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 104.814 | 104.814 | 2% | 10% | 0.102 | 0.009 | 0.001 | 0.005 | 91% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 50.233 | 50.233 | 2% | 20% | 0.201 | 0.004 | 0.001 | 0.004 | 91% |
| 3.G. Liming | $CO_2$ | 19.686 | 19.686 | 2% | 50% | 0.500 | 0.002 | 0.001 | 0.004 | 92% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 19.447 | 19.447 | 2% | 50% | 0.500 | 0.002 | 0.001 | 0.004 | 92% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 18.500 | 18.500 | 2% | 50% | 0.500 | 0.002 | 0.001 | 0.004 | 93% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 165.243 | 165.243 | 2% | 5% | 0.054 | 0.015 | 0.001 | 0.004 | 93% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 17.427 | 17.427 | 5% | 50% | 0.502 | 0.002 | 0.001 | 0.004 | 93% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 38.502 | 38.502 | 2% | 20% | 0.201 | 0.003 | 0.001 | 0.003 | 94% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 13.386 | 13.386 | 5% | 50% | 0.502 | 0.001 | 0.001 | 0.003 | 94% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 20.646 | 20.646 | 25% | 20% | 0.320 | 0.002 | 0.001 | 0.003 | 94% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 13.022 | 13.022 | 2% | 50% | 0.500 | 0.001 | 0.001 | 0.003 | 95% |
| 2.D.3. Solvent Use | $CO_2$ | 32.197 | 32.197 | 2% | 20% | 0.201 | 0.003 | 0.001 | 0.003 | 95% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 10.965 | 10.965 | 5% | 50% | 0.502 | 0.001 | 0.000 | 0.002 | 95% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 10.833 | 10.833 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.002 | 95% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 93.815 | 93.815 | 2% | 5% | 0.054 | 0.008 | 0.000 | 0.002 | 96% |
| 2.D.2 Paraffin wax use | $CO_2$ | 4.912 | 4.912 | 2% | 100% | 1.000 | 0.000 | 0.000 | 0.002 | 96% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 91.048 | 91.048 | 2% | 5% | 0.054 | 0.008 | 0.000 | 0.002 | 96% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.381 | 4.381 | 43% | 100% | 1.089 | 0.000 | 0.000 | 0.002 | 96% |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 9.442 | 9.442 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.002 | 96% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 11.522 | 11.522 | 25% | 30% | 0.391 | 0.001 | 0.000 | 0.002 | 97% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 8.434 | 8.434 | 5% | 50% | 0.502 | 0.001 | 0.000 | 0.002 | 97% |
| 2.D.1 Lubricant Use | $CO_2$ | 8.298 | 8.298 | 2% | 50% | 0.500 | 0.001 | 0.000 | 0.002 | 97% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 73.413 | 73.413 | 2% | 5% | 0.054 | 0.006 | 0.000 | 0.002 | 97% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 10.597 | 10.597 | 10% | 30% | 0.316 | 0.001 | 0.000 | 0.001 | 97% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 16.555 | 16.555 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.001 | 97% |
| 2.F.4. Aerosols | HFCs | 4.698 | 4.698 | 50% | 50% | 0.707 | 0.000 | 0.000 | 0.001 | 97% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 7.840 | 7.840 | 25% | 30% | 0.391 | 0.001 | 0.000 | 0.001 | 98% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | 107.569 | 107.569 | 2% | 2% | 0.028 | 0.009 | 0.000 | 0.001 | 98% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 26.178 | 26.178 | 2% | 11% | 0.111 | 0.002 | 0.000 | 0.001 | 98% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 5.564 | 5.564 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.001 | 98% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 13.103 | 13.103 | 2% | 20% | 0.201 | 0.001 | 0.000 | 0.001 | 98% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 26.126 | 26.126 | 10% | 0% | 0.100 | 0.002 | 0.000 | 0.001 | 98% |
| 2.G.1. Electrical equipment | SF6 | 8.578 | 8.578 | 2% | 30% | 0.301 | 0.001 | 0.000 | 0.001 | 98% |
| 3.H. Urea Application | $CO_2$ | 4.726 | 4.726 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.001 | 98% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 45.035 | 45.035 | 2% | 5% | 0.054 | 0.004 | 0.000 | 0.001 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 4.607 | 4.607 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 21.164 | 21.164 | 2% | 10% | 0.102 | 0.002 | 0.000 | 0.001 | 99% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 20.350 | 20.350 | 2% | 10% | 0.102 | 0.002 | 0.000 | 0.001 | 99% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 3.983 | 3.983 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 5.647 | 5.647 | 25% | 20% | 0.320 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 2.934 | 2.934 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 2.625 | 2.625 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.001 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 2.270 | 2.270 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 5.487 | 5.487 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 10.101 | 10.101 | 2% | 10% | 0.102 | 0.001 | 0.000 | 0.000 | 99% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 17.146 | 17.146 | 2% | 5% | 0.054 | 0.002 | 0.000 | 0.000 | 99% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 2.221 | 2.221 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 99% |
| 2.A.3. Glass production | $CO_2$ | 0.943 | 0.943 | 2% | 86% | 0.860 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 1.520 | 1.520 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 1.509 | 1.509 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 1.490 | 1.490 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 99% |
| 2.F.2 Foam blowing agents | HFCs | 0.961 | 0.961 | 50% | 50% | 0.707 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 12.580 | 12.580 | 2% | 5% | 0.054 | 0.001 | 0.000 | 0.000 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 2.207 | 2.207 | 2% | 30% | 0.301 | 0.000 | 0.000 | 0.000 | 99% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 1.276 | 1.276 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 4.555 | 4.555 | 10% | 5% | 0.112 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.949 | 0.949 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CH_4$ | 0.937 | 0.937 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 2.270 | 2.270 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 0.865 | 0.865 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.864 | 0.864 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 2.126 | 2.126 | 2% | 20% | 0.201 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.357 | 1.357 | 2% | 30% | 0.301 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 0.726 | 0.726 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.563 | 0.563 | 43% | 40% | 0.587 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 0.650 | 0.650 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 0.591 | 0.591 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 5.263 | 5.263 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - | $N_2O$ | 0.561 | 0.561 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Solid Fuels | | | | | | | | | | |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.557 | 0.557 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.550 | 0.550 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.532 | 0.532 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 2.456 | 2.456 | 2% | 10% | 0.102 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0.470 | 0.470 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 2.A.2. Lime Production | $CO_2$ | 0.460 | 0.460 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 0.431 | 0.431 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 3.907 | 3.907 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 0.370 | 0.370 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.d Urea Use | $CO_2$ | 0.817 | 0.817 | 20% | 10% | 0.224 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.351 | 0.351 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0.349 | 0.349 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.345 | 0.345 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.439 | 0.439 | 25% | 30% | 0.391 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 3.134 | 3.134 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0.335 | 0.335 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.300 | 0.300 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0.296 | 0.296 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $CO_2$ | 1.331 | 1.331 | 2% | 10% | 0.102 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 0.252 | 0.252 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 1.136 | 1.136 | 2% | 11% | 0.111 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 1.122 | 1.122 | 2% | 11% | 0.111 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 0.237 | 0.237 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0.211 | 0.211 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 0.182 | 0.182 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 0.180 | 0.180 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 0.174 | 0.174 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.347 | 0.347 | 20% | 5% | 0.206 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.131 | 0.131 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 0.127 | 0.127 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.127 | 0.127 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.G.3. $N_2O$ from product uses | $N_2O$ | 2.014 | 2.014 | 2% | 2% | 0.028 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 0.102 | 0.102 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 0.116 | 0.116 | 23% | 30% | 0.378 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 0.398 | 0.398 | 2% | 10% | 0.102 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 0.078 | 0.078 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0.076 | 0.076 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 0.705 | 0.705 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.054 | 0.054 | 20% | 60% | 0.632 | 0.000 | 0.000 | 0.000 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.049 | 0.049 | 20% | 60% | 0.632 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.052 | 0.052 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.051 | 0.051 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.050 | 0.050 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.049 | 0.049 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 0.044 | 0.044 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.043 | 0.043 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.042 | 0.042 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.040 | 0.040 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.F.3. Fire Protection | HFCs | 0.028 | 0.028 | 50% | 50% | 0.707 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0.035 | 0.035 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0.035 | 0.035 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.034 | 0.034 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.033 | 0.033 | 10% | 50% | 0.510 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.031 | 0.031 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.030 | 0.030 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.280 | 0.280 | 2% | 5% | 0.054 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.029 | 0.029 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.026 | 0.026 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.025 | 0.025 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Biomass | $CH_4$ | 0.023 | 0.023 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0.022 | 0.022 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.021 | 0.021 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.021 | 0.021 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.021 | 0.021 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.020 | 0.020 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0.019 | 0.019 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.017 | 0.017 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.015 | 0.015 | 10% | 50% | 0.510 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.011 | 0.011 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.011 | 0.011 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.009 | 0.009 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.008 | 0.008 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.011 | 0.011 | 32% | 0% | 0.322 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.007 | 0.007 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.006 | 0.006 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $N_2O$ | 0.006 | 0.006 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 0.006 | 0.006 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 0.010 | 0.010 | 5% | 25% | 0.255 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0.005 | 0.005 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.005 | 0.005 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.005 | 0.005 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.004 | 0.004 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0.004 | 0.004 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.003 | 0.003 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.003 | 0.003 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Gaseous Fuels | | | | | | | | | | |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $CH_4$ | 0.002 | 0.002 | 5% | 50% | 0.502 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0.002 | 0.002 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.g Other - Peat | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.003 | 0.003 | 10% | 0% | 0.100 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0.001 | 0.001 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000 | 0.000 | 20% | 50% | 0.539 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |

| IPCC category/Group | Gas | 2014 emissions or removals (kt $CO_2$ eq) | Absolute value of 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Level Assessment | Level Assessment with Uncertainty | Contribution to Level Assessment | Cumulative Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 0.000 | 0.000 | 2% | 50% | 0.500 | 0.000 | 0.000 | 0.000 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.000 | 0.000 | 10% | 25% | 0.269 | 0.000 | 0.000 | 0.000 | 100% |
| TOTAL | | 11353.38 | 11353.38 | | | 113.783 | 1.000 | 0.208 | 1.000 | |

## A 1.9 Spreadsheet for the Approach 1 analysis for 2014 – trend assessment with LULUCF

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass | $CO_2$ | -19117.24262 | -529.091989 | 0.906170707 | 0.379688889 | 38% |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood | $CO_2$ | 77.31120783 | -3792.439229 | 0.216429105 | 0.090684598 | 47% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.621305 | 2.456340066 | 0.149148925 | 0.062493953 | 53% |
| 4. G. Harvested wood products | $CO_2$ | -166.3561979 | -1817.58 | 0.093769333 | 0.039289699 | 57% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.1359677 | 1880.266 | 0.075266324 | 0.031536869 | 60% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.784936 | 38.5022 | 0.066902637 | 0.028032453 | 63% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.989353 | 828.0431219 | 0.057252005 | 0.023988803 | 66% |
| 4.A.1 Forest Land remaining Forest Land – Drained organic soil | $CO_2$ | 4125.54896 | 4583.280676 | 0.055031493 | 0.0230584 | 68% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.750448 | 613.35806 | 0.049990547 | 0.020946225 | 70% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.318679 | 1575.698976 | 0.041095605 | 0.017219211 | 72% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.294341 | 155.5621374 | 0.040587128 | 0.017006157 | 73% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.2058686 | 26.17773966 | 0.037606387 | 0.015757216 | 75% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.5312078 | 55.18201994 | 0.035016974 | 0.014672242 | 76% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.7039841 | 104.8142275 | 0.033074715 | 0.013858428 | 78% |
| 4.C.2 Land converted to Grassland –Mineral soil | $CO_2$ | -0.0030613 | -495.2573527 | 0.027769251 | 0.011635419 | 79% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.8184 | 50.2326 | 0.026839764 | 0.011245961 | 80% |
| 4.E.2 Land converted to Settlements – Carbon stock change – living biomass | $CO_2$ | 115.9029234 | 480.9177105 | 0.021291627 | 0.008921271 | 81% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.168965 | 91.04761992 | 0.020554294 | 0.008612325 | 82% |
| 4.A.2 Land converted to Forest Land – Carbon stock change, grassland converted to forest land | $CO_2$ | -0.15774 | -341.1744233 | 0.019122149 | 0.008012252 | 83% |
| 4.B.2 Land converted to Cropland – Carbon stock change, forest land converted to cropland | $CO_2$ | 373.3561333 | 21.17573333 | 0.017089387 | 0.007160517 | 83% |
| 3.G. Liming | $CO_2$ | 371.4186667 | 19.68633333 | 0.017078055 | 0.007155768 | 84% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.0757089 | 320.5751539 | 0.016050852 | 0.006725367 | 85% |
| 3.D.1. Direct $N_2O$ emissions from managed soils | $N_2O$ | 1962.775641 | 1429.497775 | 0.015929951 | 0.006674708 | 85% |
| 4.C.2 Land converted to Grassland – Drained organic soil | $CO_2$ | 0.0008613 | 275.3924023 | 0.015441388 | 0.006469999 | 86% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.37994 | 213.786 | 0.014025269 | 0.00587664 | 87% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 2.A.1. Cement Production | $CO_2$ | 370.8039966 | 555.775815 | 0.013010919 | 0.005451624 | 87% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.6786727 | 10.10088453 | 0.012977756 | 0.005437728 | 88% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.5769252 | 20.35027526 | 0.012251227 | 0.00513331 | 88% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.4643123 | 0.705374886 | 0.011438069 | 0.004792593 | 89% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.4838285 | 73.41324777 | 0.011278448 | 0.004725712 | 89% |
| 4.B.1 Cropland remaining Cropland – Drained organic soil | $CO_2$ | 2761.364974 | 2598.776785 | 0.01053932 | 0.004416014 | 90% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 16.555 | 0.009745995 | 0.004083608 | 90% |
| 4.E.2 Land converted to Settlements – Organic soils | $CO_2$ | 3.765666667 | 166.1761669 | 0.009133267 | 0.003826873 | 90% |
| 4.E.2 Land converted to Settlements – Carbon stock change – dead organic matter | $CO_2$ | 45.65085251 | 197.4969716 | 0.008839059 | 0.003703598 | 91% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $N_2O$ | 567.421657 | 638.8013455 | 0.008041284 | 0.003369328 | 91% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CO_2$ | 256.17754 | 88.88382 | 0.007556763 | 0.003166312 | 91% |
| 3.D.2 Indirect $N_2O$ Emissions from managed soils | $N_2O$ | 377.2229002 | 196.0440499 | 0.007473695 | 0.003131506 | 92% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.95737306 | 165.2425801 | 0.007456102 | 0.003124134 | 92% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.9110639 | 157.1324033 | 0.007339463 | 0.003075262 | 92% |
| 2.A.2. Lime Production | $CO_2$ | 148.8573814 | 0.459881348 | 0.007261158 | 0.003042452 | 93% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.4154681 | 5.263181843 | 0.007019154 | 0.002941052 | 93% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.826737 | 0 | 0.006991729 | 0.00292956 | 93% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 4.C.1 Grassland remaining Grassland – Drained organic soil | $CO_2$ | 924.832656 | 684.0066031 | 0.006920197 | 0.002899588 | 94% |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | 147.0542333 | 8.696233333 | 0.006711072 | 0.002811964 | 94% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 392.8311633 | 227.8019525 | 0.006457073 | 0.002705538 | 94% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – living biomass | $CO_2$ | -65.31052768 | -165.2320183 | 0.006067551 | 0.002542327 | 94% |
| 4.E.2 Land converted to Settlements – Mineral soils | $CO_2$ | 1.399566667 | 107.2922807 | 0.005947435 | 0.002491998 | 95% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.4292 | 118.6284 | 0.005847321 | 0.002450049 | 95% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 56.12604453 | 149.8529208 | 0.005654839 | 0.002369399 | 95% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 103.071464 | 2.2704 | 0.004918305 | 0.002060788 | 95% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.28152 | 2.2704 | 0.004879636 | 0.002044585 | 96% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, dead wood | $CO_2$ | -1.612112333 | -83.797142 | 0.004619643 | 0.001935648 | 96% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.25228881 | 0 | 0.004564935 | 0.001912725 | 96% |
| 4.B.2 Land converted to Cropland – Drained organic soil | $CO_2$ | 12.45566667 | 89.507 | 0.004408979 | 0.001847379 | 96% |
| 3.B.5 Indirect $N_2O$ emissions from Manure Management | $N_2O$ | 137.5202478 | 41.93797066 | 0.004380474 | 0.001835435 | 96% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 109.5074001 | 0.004030959 | 0.001688987 | 96% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, litter | $CO_2$ | -1.3821621 | -71.8444518 | 0.003960705 | 0.00165955 | 97% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – living biomass | $CO_2$ | -48.28378427 | -108.185671 | 0.003702428 | 0.001551331 | 97% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.83865681 | 0 | 0.003614588 | 0.001514526 | 97% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 120.6657672 | 42.94734024 | 0.003498808 | 0.001466014 | 97% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.2220665 | 93.81485986 | 0.00326835 | 0.001369451 | 97% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.54499789 | 1.136164465 | 0.00319384 | 0.001338231 | 97% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | 61.3521 | 0 | 0.00300334 | 0.001258411 | 97% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 334.0088098 | 238.7965288 | 0.002961097 | 0.001240711 | 98% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.184752 | 10.8326905 | 0.002779372 | 0.001164567 | 98% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.59606386 | 0.01036233 | 0.002574129 | 0.00107857 | 98% |
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 109.190125 | 0.002553886 | 0.001070088 | 98% |
| 4.B.2 Land converted to Cropland –Mineral soil | $CO_2$ | 6.935133333 | 48.7498 | 0.002393941 | 0.00100307 | 98% |
| 4.E.2 Lands converted to settlements, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0.910565999 | 40.47931849 | 0.002225127 | 0.000932337 | 98% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.6011945 | 230.7118474 | 0.002186131 | 0.000915997 | 98% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.03 | 3.9825 | 0.002127888 | 0.000891593 | 98% |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.27150449 | 0 | 0.002069297 | 0.000867043 | 98% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.37841625 | 20.64571937 | 0.002042819 | 0.000855949 | 98% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344325 | 26.126175 | 0.001978621 | 0.000829049 | 99% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change –organic soils | $CO_2$ | 277.2 | 277.2 | 0.001973145 | 0.000826755 | 99% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.54125 | 13.1025 | 0.001837361 | 0.000769861 | 99% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 40.75322335 | 5.647103039 | 0.001678336 | 0.000703229 | 99% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.20060747 | 24.62371876 | 0.001615256 | 0.000676798 | 99% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.9670107 | 70.59473241 | 0.001473823 | 0.000617537 | 99% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – living biomass | $CO_2$ | -19.17968712 | -42.87716154 | 0.001465256 | 0.000613948 | 99% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 137.025 | 138.525 | 0.001059467 | 0.000443921 | 99% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263264 | 5.4868 | 0.001026957 | 0.000430299 | 99% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.42474185 | 101.6540154 | 0.000979572 | 0.000410444 | 99% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – dead organic matter | $CO_2$ | -13.80988549 | -29.46614791 | 0.000976157 | 0.000409014 | 99% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455344 | 17.42704 | 0.000954855 | 0.000400088 | 99% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.6165255 | 0 | 0.000862373 | 0.000361338 | 99% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.593827044 | 19.44722022 | 0.000816586 | 0.000342153 | 99% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CH_4$ | 25.2045 | 8.745 | 0.000743486 | 0.000311523 | 99% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.54739345 | 0.397748377 | 0.000738782 | 0.000309552 | 99% |

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|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.519712 | 13.38625669 | 0.000725135 | 0.000303834 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.15516309 | 2.207274532 | 0.000716025 | 0.000300017 | 99% |
| 2.D.1 Lubricant Use | $CO_2$ | 23.25102433 | 8.297813333 | 0.000672933 | 0.000281961 | 99% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CO_2$ | 1016.928 | 899.740705 | 0.000667854 | 0.000279833 | 99% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.8332289 | 12.58 | 0.00066458 | 0.000278462 | 99% |
| 4.C. Grassland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 69.98791354 | 72.89522859 | 0.000661198 | 0.000277044 | 100% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.2865 | 10.965 | 0.00060079 | 0.000251733 | 100% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.92 | 18.5 | 0.00057421 | 0.000240596 | 100% |
| 4.B. Cropland remaining cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 125.0975756 | 119.0448062 | 0.000551078 | 0.000230904 | 100% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.98598703 | 11.52240459 | 0.000479153 | 0.000200767 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 8.434081116 | 0.000456897 | 0.000191442 | 100% |
| 4.A.1 Forest land remaining forest land - wildfires | $CH_4$ | 2.525 | 9.198 | 0.000392133 | 0.000164305 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 0.18 | 0.000386863 | 0.000162097 | 100% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 13.07410741 | 4.606850327 | 0.000381701 | 0.000159934 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.1626684 | 0.0057514 | 0.000350308 | 0.00014678 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.69904433 | 45.0354735 | 0.000337037 | 0.00014122 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.66618252 | 0.181929 | 0.000316126 | 0.000132458 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.15 | 2.625286653 | 0.000300714 | 0.000126 | 100% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – dead organic matter | $CO_2$ | -6.10842148 | -10.61212032 | 0.000296006 | 0.000124028 | 100% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687214 | 16.53660558 | 0.000281283 | 0.000117859 | 100% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – dead organic matter | $CO_2$ | -4.284491677 | -8.55723594 | 0.000270073 | 0.000113162 | 100% |
| 4.B.2 Land converted to cropland, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0.590489444 | 4.882747284 | 0.000244873 | 0.000102603 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.26924002 | 33.54418198 | 0.000237294 | 9.94272E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.286318275 | 0.590724755 | 0.000225656 | 9.45508E-05 | 100% |
| 2.D.3. Solvent Use | $CO_2$ | 41.0641984 | 32.19721064 | 0.000204878 | 8.58445E-05 | 100% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CH_4$ | 28.53444375 | 28.53444375 | 0.000203112 | 8.51046E-05 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.42449305 | 17.14603569 | 0.000185299 | 7.76408E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.72829 | 0.10175 | 0.000176804 | 7.40815E-05 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.054819072 | 3.13427 | 0.000173057 | 7.25115E-05 | 100% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.4845375 | 7.840283798 | 0.00017154 | 7.18758E-05 | 100% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – living biomass | $CO_2$ | -6.124066667 | -8.288426667 | 0.000164949 | 6.91142E-05 | 100% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.163685304 | 2.934347457 | 0.000156518 | 6.55816E-05 | 100% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 8.94447 | 10.597476 | 0.000156353 | 6.55125E-05 | 100% |
| 1.A.4.b Residential - Peat | $CH_4$ | 3.1875 | 0 | 0.000156036 | 6.53797E-05 | 100% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.090525 | 13.021775 | 0.000155437 | 6.51289E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.0786 | 0 | 0.000150705 | 6.31461E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.0225 | 0 | 0.000147959 | 6.19954E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.00505 | 0.002425 | 0.000146969 | 6.15805E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 0.649625 | 0.000134664 | 5.64248E-05 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692316 | 0 | 0.000131796 | 5.52229E-05 | 100% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.862588 | 0.237357 | 0.000126822 | 5.31389E-05 | 100% |
| 3.H. Urea Application | $CO_2$ | 7.7088 | 4.726333333 | 0.000112357 | 4.70778E-05 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.341428614 | 0.115643072 | 0.000108135 | 4.53088E-05 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.26531 | 0.173975 | 0.000101138 | 4.23771E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.411706848 | 0.369840648 | 9.73219E-05 | 4.07782E-05 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.149772 | 0.252487056 | 9.10796E-05 | 3.81627E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.87891384 | 0.0437464 | 8.95247E-05 | 3.75112E-05 | 100% |
| 5.B.1. Composting | $CH_4$ | 23.90918253 | 22.4652 | 8.92235E-05 | 3.7385E-05 | 100% |

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|---|---|---|---|---|---|---|
| 4.A.1 Forest land remaining forest land - Controlled burning | $N_2O$ | 2.95616 | 1.02512 | 8.72323E-05 | 3.65507E-05 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.4629 | 4.554798669 | 8.58728E-05 | 3.5981E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008344 | 1.509107769 | 8.42082E-05 | 3.52835E-05 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.1006644 | 1.5198 | 8.02884E-05 | 3.36411E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774375 | 0.127125 | 7.97321E-05 | 3.34081E-05 | 100% |
| 5.B.1. Composting | $N_2O$ | 17.09984734 | 16.06711104 | 6.38127E-05 | 2.67378E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.00525 | 0.949410006 | 5.2977E-05 | 2.21976E-05 | 100% |
| 2.G.3. $N_2O$ from product uses | $N_2O$ | 1.30226 | 2.01448 | 4.92043E-05 | 2.06168E-05 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.997704 | 0 | 4.88401E-05 | 2.04642E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.45424 | 0.431444174 | 4.69974E-05 | 1.96921E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030335 | 0.078225 | 4.60514E-05 | 1.92957E-05 | 100% |
| 4.A.1 Forest land remaining forest land - wildfires | $N_2O$ | 0.295616 | 1.078462 | 4.59989E-05 | 1.92737E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 34.97326278 | 4.52166E-05 | 1.89459E-05 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.124565463 | 0.863788568 | 4.23354E-05 | 1.77387E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.78871 | 0.02035 | 3.74683E-05 | 1.56994E-05 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.355752064 | 0.942744575 | 3.54453E-05 | 1.48517E-05 | 100% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.824479542 | 2.221483039 | 3.52471E-05 | 1.47687E-05 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $N_2O$ | 0.053992802 | 0.663123844 | 3.45387E-05 | 1.44718E-05 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.7015 | 0 | 3.43402E-05 | 1.43887E-05 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $CH_4$ | 0.049609865 | 0.609294045 | 3.1735E-05 | 1.32971E-05 | 100% |

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|---|---|---|---|---|---|---|
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.65129688 | 0.0069732 | 3.14916E-05 | 1.31951E-05 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.62775 | 0 | 3.07299E-05 | 1.2876E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.615519 | 0 | 3.01312E-05 | 1.26251E-05 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868375 | 1.276125 | 2.9044E-05 | 1.21695E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.64092648 | 0.04917 | 2.8618E-05 | 1.1991E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.07599 | 0.560538 | 2.77098E-05 | 1.16105E-05 | 100% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $N_2O$ | 3.793114158 | 3.793114158 | 2.69999E-05 | 1.1313E-05 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.7792529 | 21.16428627 | 2.63117E-05 | 1.10247E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.4832964 | 0.010728 | 2.30571E-05 | 9.66099E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.47777148 | 0.010728 | 2.27866E-05 | 9.54767E-06 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.108041461 | 1.356526416 | 2.18199E-05 | 9.14262E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.4367772 | 0.865392 | 2.18108E-05 | 9.1388E-06 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.745009038 | 0.299750179 | 1.96629E-05 | 8.23882E-06 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423011 | 0.0303066 | 1.90081E-05 | 7.96448E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.20535 | 0.726 | 1.82976E-05 | 7.66678E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.271776 | 0.556962 | 1.79251E-05 | 7.51068E-06 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.3177723 | 0 | 1.55558E-05 | 6.51792E-06 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.011005031 | 0.28 | 1.51611E-05 | 6.35254E-06 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.2955862 | 0.004619 | 1.42107E-05 | 5.95434E-06 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.78185 | 0.439375 | 1.36375E-05 | 5.71416E-06 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.27267 | 0 | 1.33479E-05 | 5.59281E-06 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273195 | 0.004725 | 1.31087E-05 | 5.49257E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.268845 | 0.020625 | 1.20042E-05 | 5.0298E-06 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CH_4$ | 0.2325 | 0 | 1.13815E-05 | 4.76887E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.3505 | 1.12819E-05 | 4.72715E-06 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.28480456 | 0.0500044 | 1.11381E-05 | 4.66691E-06 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.172771761 | 0.3465 | 1.09709E-05 | 4.59683E-06 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.2179572 | 0 | 1.06696E-05 | 4.47058E-06 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.23893 | 0.04195 | 9.34406E-06 | 3.9152E-06 | 100% |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.1860712 | 0 | 9.10865E-06 | 3.81656E-06 | 100% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.847024532 | 4.3807102 | 8.35519E-06 | 3.50085E-06 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.810707594 | 0.56263867 | 8.13867E-06 | 3.41013E-06 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.168 | 0.00275 | 8.06983E-06 | 3.38129E-06 | 100% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 6.219856 | 5.564080248 | 7.50395E-06 | 3.14418E-06 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.76125 | 0.550125 | 6.41924E-06 | 2.68969E-06 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127395 | 0.0003874 | 6.21458E-06 | 2.60393E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.1708732 | 0.0403194 | 6.10394E-06 | 2.55757E-06 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 4.B.1 Cropland remaining Cropland – Carbon stock change – dead organic matter | $CO_2$ | -1.368033333 | -1.2914 | 5.44095E-06 | 2.27978E-06 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.5005 | 0.5315 | 5.30081E-06 | 2.22106E-06 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.106875 | 0.000325 | 5.21358E-06 | 2.18451E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.14335 | 0.033825 | 5.12075E-06 | 2.14562E-06 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.12419448 | 0.025926 | 4.62595E-06 | 1.93829E-06 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091425 | 0 | 4.47548E-06 | 1.87524E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.08118414 | 0.0028906 | 3.81209E-06 | 1.59728E-06 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.06875 | 1.15638E-05 | 3.36484E-06 | 1.40988E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.0681075 | 0.002425 | 3.19806E-06 | 1.34E-06 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.001463305 | 0.054450618 | 2.98145E-06 | 1.24924E-06 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.4500694 | 0.344594088 | 2.71042E-06 | 1.13568E-06 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.002972338 | 0.049156808 | 2.61075E-06 | 1.09391E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.057625 | 0.004375 | 2.57558E-06 | 1.07918E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050064 | 0 | 2.45076E-06 | 1.02688E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.0362964 | 0.0004768 | 1.75007E-06 | 7.33284E-07 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.09466268 | 0.0515242 | 1.74498E-06 | 7.31154E-07 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034425 | 0 | 1.68519E-06 | 7.06101E-07 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.000453151 | 0.029353 | 1.62366E-06 | 6.80319E-07 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.00425 | 0.03135 | 1.54977E-06 | 6.49358E-07 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CH_4$ | 0.0315 | 0 | 1.542E-06 | 6.46106E-07 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181482 | 0.1311498 | 1.53035E-06 | 6.41221E-07 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079415 | 0.043225 | 1.46391E-06 | 6.13384E-07 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.026721 | 0.0006 | 1.27442E-06 | 5.33986E-07 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.1193192 | 0.1267096 | 1.26371E-06 | 5.29501E-07 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001126 | 0.017 | 8.9808E-07 | 3.76299E-07 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.0177725 | 0 | 8.70009E-07 | 3.64537E-07 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015225 | 0.00025 | 7.31284E-07 | 3.06411E-07 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.02384 | 0.032918912 | 6.78757E-07 | 2.84402E-07 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.013857 | 0 | 6.78335E-07 | 2.84225E-07 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.01272162 | 0 | 6.22755E-07 | 2.60937E-07 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.02475 | 0.014988474 | 3.71161E-07 | 1.55518E-07 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.006946 | 0.00145 | 2.58722E-07 | 1.08405E-07 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.05379496 | 0.0511368 | 2.33875E-07 | 9.79943E-08 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.024287 | 0.024734 | 1.97942E-07 | 8.29382E-08 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.008686 | 0.011105 | 1.97463E-07 | 8.27377E-08 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.00295205 | 0.005924494 | 1.8768E-07 | 7.86386E-08 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020375 | 0.02075 | 1.66058E-07 | 6.95791E-08 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 9.36998E-05 | 0.002384 | 1.29086E-07 | 5.40873E-08 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.000009504 | 0.0021375 | 1.19386E-07 | 5.00231E-08 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.01272758 | 0.0094168 | 9.50411E-08 | 3.98226E-08 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.0106775 | 0.0079 | 7.97324E-08 | 3.34082E-08 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.02314 | 0.02145 | 6.9954E-08 | 2.9311E-08 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.0007115 | 0 | 3.48297E-08 | 1.45938E-08 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000219506 | 0.000440227 | 1.39385E-08 | 5.84027E-09 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.002806 | 0.002657 | 1.16189E-08 | 4.86838E-09 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 1.96519E-06 | 0.00005 | 2.70733E-09 | 1.13438E-09 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0 | 0.2955 | | 0 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0 | 0.469648 | | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 0 | 3.906691677 | | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0 | 0.0018 | | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0 | 0.0021456 | | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 0 | 1.12172959 | | 0 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0 | 0.211451058 | | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0 | 0.000521299 | | 0 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0 | 0.334983061 | | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0 | 0.004850822 | | 0 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $CH_4$ | 0 | 0.00225 | | 0 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0 | 0.003576 | | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 0 | 2.1257 | | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0 | 0.02175 | | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0 | 0.034568 | | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | 0 | 107.5693 | | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CH_4$ | 0 | 0.937280723 | | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 0 | 1.489651495 | | 0 | 100% |
| 1.A.2.g Other - Peat | $CO_2$ | 0 | 1.331164465 | | 0 | 100% |
| 1.A.2.g Other - Peat | $CH_4$ | 0 | 0.000575 | | 0 | 100% |
| 1.A.2.g Other - Peat | $N_2O$ | 0 | 0.005811 | | 0 | 100% |
| 1.A.3.b Road Transportation - Biomass | $CH_4$ | 0 | 0.023009615 | | 0 | 100% |
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0 | 0.349076786 | | 0 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0 | 0.0022825 | | 0 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0 | 0.0346276 | | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 0 | 9.442494289 | | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0 | 0.018743571 | | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0 | 0.076423393 | | 0 | 100% |
| 2.D.2 Paraffin wax use | $CO_2$ | 0 | 4.911573333 | | 0 | 100% |
| 2.D.3.d Urea Use | $CO_2$ | 0 | 0.817 | | 0 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 2.F.1. Refrigeration and air conditioning | HFCs | 0 | 206.3769351 | | 0 | 100% |
| 2.F.2 Foam blowing agents | HFCs | 0 | 0.961490119 | | 0 | 100% |
| 2.F.3. Fire Protection | HFCs | 0 | 0.02767976 | | 0 | 100% |
| 2.F.4. Aerosols | HFCs | 0 | 4.697766137 | | 0 | 100% |
| 2.G.1. Electrical equipment | SF6 | 0 | 8.577903643 | | 0 | 100% |
| 4.A.2 Land converted to Forest Land – grassland converted to forest land, Drained organic soil | $CO_2$ | 0 | 61.24812203 | | 0 | 100% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CO_2$ | 0 | 22.06783674 | | 0 | 100% |
| 4.B.2 Wetlands converted to cropland, organic soil | $CO_2$ | 0 | 3.8236 | | 0 | 100% |
| 4.B.2 Settlements converted to cropland, mineral soils | $CO_2$ | 0 | 5.310433333 | | 0 | 100% |
| 4.E.1 Settlements remaining Settlements – Drained organic soils | $CO_2$ | 0 | 19.43012935 | | 0 | 100% |
| 4.E.2 Settlements remaining Settlements, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0 | 4.083489381 | | 0 | 100% |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 0 | 301.0244136 | | 0 | 100% |
| TOTAL | | 17834.80 | 15573.52 | 2.386613709 | 1 | |

## A 1.10 Spreadsheet for the Approach 1 analysis for 2014 – trend assessment without LULUCF

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.1359677 | 1880.266 | 0.061464797 | 0.181518726 | 18% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.621305 | 2.456340066 | 0.05012911 | 0.148042013 | 33% |
| 3.D.1. Direct $N_2O$ emissions from managed soils | $N_2O$ | 1962.775641 | 1429.497775 | 0.022119758 | 0.065324391 | 39% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.784936 | 38.5022 | 0.021767108 | 0.064282939 | 46% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.318679 | 1575.698976 | 0.016463977 | 0.048621656 | 51% |
| 2.A.1. Cement Production | $CO_2$ | 370.8039966 | 555.775815 | 0.015060641 | 0.044477302 | 55% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.2058686 | 26.17773966 | 0.012148244 | 0.035876369 | 59% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.5312078 | 55.18201994 | 0.010719577 | 0.031657211 | 62% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.294341 | 155.5621374 | 0.010663894 | 0.031492765 | 65% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.7039841 | 104.8142275 | 0.0091121 | 0.026909985 | 68% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.8184 | 50.2326 | 0.008063761 | 0.023814016 | 70% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.95737306 | 165.2425801 | 0.005684781 | 0.016788376 | 72% |
| 3.G. Liming | $CO_2$ | 371.4186667 | 19.68633333 | 0.005366933 | 0.015849705 | 73% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.6011945 | 230.7118474 | 0.005170368 | 0.015269207 | 75% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.168965 | 91.04761992 | 0.005164641 | 0.015252293 | 77% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.750448 | 613.35806 | 0.005027274 | 0.014846619 | 78% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.4292 | 118.6284 | 0.004247505 | 0.012543795 | 79% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.6786727 | 10.10088453 | 0.004171779 | 0.012320158 | 80% |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.4643123 | 0.705374886 | 0.003834409 | 0.011323831 | 82% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.5769252 | 20.35027526 | 0.003730341 | 0.011016496 | 83% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 334.0088098 | 238.7965288 | 0.00359416 | 0.010614325 | 84% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.989353 | 828.0431219 | 0.00334332 | 0.009873541 | 85% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 137.025 | 138.525 | 0.003019255 | 0.008916506 | 86% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 16.555 | 0.002960492 | 0.008742967 | 87% |
| 2.A.2. Lime Production | $CO_2$ | 148.8573814 | 0.459881348 | 0.002433941 | 0.007187951 | 87% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.4838285 | 73.41324777 | 0.002383064 | 0.0070377 | 88% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.826737 | 0 | 0.002352141 | 0.006946376 | 89% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.42474185 | 101.6540154 | 0.002283615 | 0.006744004 | 89% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.4154681 | 5.263181843 | 0.002260194 | 0.006674839 | 90% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 392.8311633 | 227.8019525 | 0.002206706 | 0.006516877 | 91% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 103.071464 | 2.2704 | 0.001610961 | 0.004757514 | 91% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.28152 | 2.2704 | 0.001597952 | 0.004719095 | 92% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.25228881 | 0 | 0.001535725 | 0.004535324 | 92% |
| 3.D.2 Indirect $N_2O$ Emissions from managed soils | $N_2O$ | 377.2229002 | 196.0440499 | 0.001254222 | 0.003703988 | 92% |
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 109.190125 | 0.001239762 | 0.003661283 | 93% |

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|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.83865681 | 0 | 0.001216011 | 0.003591142 | 93% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.54499789 | 1.136164465 | 0.001052624 | 0.003108624 | 93% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | 61.3521 | 0 | 0.001010377 | 0.002983859 | 94% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.69904433 | 45.0354735 | 0.000979091 | 0.002891465 | 94% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.59606386 | 0.01036233 | 0.000865783 | 0.002556843 | 94% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.9670107 | 70.59473241 | 0.000861205 | 0.002543322 | 95% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.0757089 | 320.5751539 | 0.000762546 | 0.002251961 | 95% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 109.5074001 | 0.000748947 | 0.002211802 | 95% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.184752 | 10.8326905 | 0.000726796 | 0.002146384 | 95% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.2220665 | 93.81485986 | 0.000703849 | 0.002078617 | 95% |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.27150449 | 0 | 0.000696148 | 0.002055874 | 96% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 34.97326278 | 0.000687494 | 0.002030317 | 96% |
| 3.B.5 Indirect $N_2O$ emissions from Manure Management | $N_2O$ | 137.5202478 | 41.93797066 | 0.000667506 | 0.001971287 | 96% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455344 | 17.42704 | 0.000656226 | 0.001937975 | 96% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.593827044 | 19.44722022 | 0.000648543 | 0.001915287 | 96% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.03 | 3.9825 | 0.000639305 | 0.001888003 | 97% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.37994 | 213.786 | 0.000608793 | 0.001797897 | 97% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.26924002 | 33.54418198 | 0.000564981 | 0.001668511 | 97% |

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| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.9110639 | 157.1324033 | 0.000551392 | 0.001628378 | 97% |
| 2.D.3. Solvent Use | $CO_2$ | 41.0641984 | 32.19721064 | 0.000549994 | 0.001624251 | 97% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.519712 | 13.38625669 | 0.000501269 | 0.001480354 | 97% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.8332289 | 12.58 | 0.000465399 | 0.001374422 | 98% |
| 5.B.1. Composting | $CH_4$ | 23.90918253 | 22.4652 | 0.000461859 | 0.001363969 | 98% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 40.75322335 | 5.647103039 | 0.000456069 | 0.00134687 | 98% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.2865 | 10.965 | 0.000412894 | 0.001219364 | 98% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.7792529 | 21.16428627 | 0.000397984 | 0.001175332 | 98% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.54125 | 13.1025 | 0.000366255 | 0.001081628 | 98% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 120.6657672 | 42.94734024 | 0.000351495 | 0.00103804 | 98% |
| 5.B.1. Composting | $N_2O$ | 17.09984734 | 16.06711104 | 0.000330322 | 0.000975511 | 98% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 8.434081116 | 0.000315834 | 0.000932727 | 98% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.37841625 | 20.64571937 | 0.000290373 | 0.000857534 | 99% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.6165255 | 0 | 0.000290118 | 0.000856779 | 99% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.42449305 | 17.14603569 | 0.000267256 | 0.000789265 | 99% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 8.94447 | 10.597476 | 0.000256313 | 0.000756946 | 99% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.54739345 | 0.397748377 | 0.000240894 | 0.00071141 | 99% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263264 | 5.4868 | 0.000240015 | 0.000708816 | 99% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687214 | 16.53660558 | 0.00022325 | 0.000659306 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.15516309 | 2.207274532 | 0.000198454 | 0.000586076 | 99% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.090525 | 13.021775 | 0.000198022 | 0.000584803 | 99% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344325 | 26.126175 | 0.000163426 | 0.000482632 | 99% |

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| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.92 | 18.5 | 0.000162446 | 0.000479739 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 0.18 | 0.000126688 | 0.000374135 | 99% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.054819072 | 3.13427 | 0.000118469 | 0.000349864 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.1626684 | 0.0057514 | 0.000117739 | 0.000347709 | 99% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.4629 | 4.554798669 | 0.000116445 | 0.000343887 | 99% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 6.219856 | 5.564080248 | 0.000109481 | 0.000323322 | 99% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.163685304 | 2.934347457 | 0.000109062 | 0.000322082 | 99% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.66618252 | 0.181929 | 0.000102853 | 0.000303747 | 99% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.4845375 | 7.840283798 | 9.30028E-05 | 0.000274657 | 99% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.847024532 | 4.3807102 | 8.70201E-05 | 0.000256989 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.20060747 | 24.62371876 | 7.00651E-05 | 0.000206917 | 100% |
| 2.D.1 Lubricant Use | $CO_2$ | 23.25102433 | 8.297813333 | 6.68796E-05 | 0.00019751 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.286318275 | 0.590724755 | 6.45594E-05 | 0.000190658 | 100% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.98598703 | 11.52240459 | 6.02966E-05 | 0.000178069 | 100% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.72829 | 0.10175 | 5.75241E-05 | 0.000169881 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008344 | 1.509107769 | 5.73383E-05 | 0.000169332 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.1006644 | 1.5198 | 5.62252E-05 | 0.000166045 | 100% |
| 2.G.3. $N_2O$ from product uses | $N_2O$ | 1.30226 | 2.01448 | 5.5277E-05 | 0.000163245 | 100% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.824479542 | 2.221483039 | 5.45608E-05 | 0.00016113 | 100% |
| 3.H. Urea Application | $CO_2$ | 7.7088 | 4.726333333 | 5.30544E-05 | 0.000156681 | 100% |
| 1.A.4.b Residential - Peat | $CH_4$ | 3.1875 | 0 | 5.24933E-05 | 0.000155024 | 100% |

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| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.15 | 2.625286653 | 5.07003E-05 | 0.000149729 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.0786 | 0 | 5.06999E-05 | 0.000149728 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.0225 | 0 | 4.9776E-05 | 0.000146999 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.00505 | 0.002425 | 4.93963E-05 | 0.000145878 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692316 | 0 | 4.43384E-05 | 0.000130941 | 100% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 13.07410741 | 4.606850327 | 3.98548E-05 | 0.0001177 | 100% |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.862588 | 0.237357 | 3.81026E-05 | 0.000112525 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.00525 | 0.949410006 | 3.60727E-05 | 0.00010653 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868375 | 1.276125 | 3.43015E-05 | 0.0001013 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.341428614 | 0.115643072 | 3.41554E-05 | 0.000100868 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.108041461 | 1.356526416 | 3.34168E-05 | 9.86869E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 0.649625 | 3.28158E-05 | 9.69122E-05 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.124565463 | 0.863788568 | 3.08468E-05 | 9.10971E-05 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.26531 | 0.173975 | 3.06802E-05 | 9.06053E-05 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.355752064 | 0.942744575 | 3.00466E-05 | 8.8734E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.87891384 | 0.0437464 | 2.92768E-05 | 8.64605E-05 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.149772 | 0.252487056 | 2.57873E-05 | 7.61554E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.411706848 | 0.369840648 | 2.56315E-05 | 7.56952E-05 | 100% |

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|---|---|---|---|---|---|---|
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774375 | 0.127125 | 2.43796E-05 | 7.19982E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.07599 | 0.560538 | 2.00972E-05 | 5.93512E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.271776 | 0.556962 | 1.67367E-05 | 4.94269E-05 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.997704 | 0 | 1.64307E-05 | 4.85233E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030335 | 0.078225 | 1.39888E-05 | 4.13119E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.78871 | 0.02035 | 1.22138E-05 | 3.607E-05 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.5005 | 0.5315 | 1.20002E-05 | 3.54391E-05 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.7015 | 0 | 1.15526E-05 | 3.41174E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.3505 | 1.0533E-05 | 3.11062E-05 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.011005031 | 0.28 | 1.04828E-05 | 3.0958E-05 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.65129688 | 0.0069732 | 1.04603E-05 | 3.08915E-05 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.172771761 | 0.3465 | 1.03515E-05 | 3.05701E-05 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.62775 | 0 | 1.03381E-05 | 3.05306E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.615519 | 0 | 1.01367E-05 | 2.99358E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.4367772 | 0.865392 | 9.29768E-06 | 2.7458E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.64092648 | 0.04917 | 8.68241E-06 | 2.5641E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.76125 | 0.550125 | 8.41537E-06 | 2.48524E-05 | 100% |

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| 5.C.1 Waste Incineration | $CO_2$ | 0.810707594 | 0.56263867 | 8.07747E-06 | 2.38545E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.20535 | 0.726 | 7.80007E-06 | 2.30353E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.4832964 | 0.010728 | 7.55058E-06 | 2.22985E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.45424 | 0.431444174 | 7.5172E-06 | 2.21999E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.47777148 | 0.010728 | 7.45959E-06 | 2.20298E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423011 | 0.0303066 | 5.8121E-06 | 1.71644E-05 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.4500694 | 0.344594088 | 5.71221E-06 | 1.68694E-05 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.3177723 | 0 | 5.23323E-06 | 1.54549E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.2955862 | 0.004619 | 4.69194E-06 | 1.38563E-05 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.27267 | 0 | 4.49046E-06 | 1.32613E-05 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273195 | 0.004725 | 4.31915E-06 | 1.27554E-05 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.78185 | 0.439375 | 3.8581E-06 | 1.13938E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CH_4$ | 0.2325 | 0 | 3.82892E-06 | 1.13076E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.268845 | 0.020625 | 3.64195E-06 | 1.07555E-05 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.2179572 | 0 | 3.58943E-06 | 1.06003E-05 | 100% |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.1860712 | 0 | 3.06431E-06 | 9.04957E-06 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.1193192 | 0.1267096 | 2.86084E-06 | 8.44868E-06 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.28480456 | 0.0500044 | 2.78584E-06 | 8.22718E-06 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.168 | 0.00275 | 2.66197E-06 | 7.86137E-06 | 100% |

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| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.23893 | 0.04195 | 2.33711E-06 | 6.902E-06 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127395 | 0.0003874 | 2.08325E-06 | 6.15228E-06 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.001463305 | 0.054450618 | 2.0497E-06 | 6.05321E-06 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181482 | 0.1311498 | 2.00622E-06 | 5.92481E-06 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.002972338 | 0.049156808 | 1.82323E-06 | 5.38439E-06 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.106875 | 0.000325 | 1.74769E-06 | 5.16131E-06 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091425 | 0 | 1.50563E-06 | 4.44645E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.1708732 | 0.0403194 | 1.27842E-06 | 3.77546E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.08118414 | 0.0028906 | 1.22689E-06 | 3.62327E-06 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.06875 | 1.15638E-05 | 1.13177E-06 | 3.34235E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.00425 | 0.03135 | 1.124E-06 | 3.31942E-06 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.000453151 | 0.029353 | 1.11047E-06 | 3.27946E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.14335 | 0.033825 | 1.0725E-06 | 3.16733E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.05379496 | 0.0511368 | 1.06167E-06 | 3.13534E-06 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.12419448 | 0.025926 | 1.05788E-06 | 3.12415E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.0681075 | 0.002425 | 1.02927E-06 | 3.03965E-06 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.02384 | 0.032918912 | 8.61138E-07 | 2.54312E-06 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.745009038 | 0.299750179 | 8.52919E-07 | 2.51885E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050064 | 0 | 8.24479E-07 | 2.43486E-06 | 100% |

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| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.057625 | 0.004375 | 7.82371E-07 | 2.31051E-06 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001126 | 0.017 | 6.28917E-07 | 1.85733E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.0362964 | 0.0004768 | 5.79588E-07 | 1.71165E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034425 | 0 | 5.66928E-07 | 1.67426E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.024287 | 0.024734 | 5.42046E-07 | 1.60078E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CH_4$ | 0.0315 | 0 | 5.18757E-07 | 1.532E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020375 | 0.02075 | 4.54737E-07 | 1.34294E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.02314 | 0.02145 | 4.35862E-07 | 1.28719E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.026721 | 0.0006 | 4.17203E-07 | 1.23209E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.09466268 | 0.0515242 | 4.03394E-07 | 1.19131E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079415 | 0.043225 | 3.38418E-07 | 9.99421E-07 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.0177725 | 0 | 2.92686E-07 | 8.64365E-07 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.008686 | 0.011105 | 2.79899E-07 | 8.26601E-07 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015225 | 0.00025 | 2.41211E-07 | 7.12349E-07 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.013857 | 0 | 2.28204E-07 | 6.73935E-07 | 100% |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.01272162 | 0 | 2.09506E-07 | 6.18716E-07 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.00295205 | 0.005924494 | 1.77024E-07 | 5.2279E-07 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.02475 | 0.014988474 | 1.63254E-07 | 4.82125E-07 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.01272758 | 0.0094168 | 1.49043E-07 | 4.40157E-07 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.0106775 | 0.0079 | 1.25036E-07 | 3.69259E-07 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 9.36998E-05 | 0.002384 | 8.92537E-08 | 2.63585E-07 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.000009504 | 0.0021375 | 8.12521E-08 | 2.39955E-07 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.006946 | 0.00145 | 5.91656E-08 | 1.74729E-07 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.002806 | 0.002657 | 5.49837E-08 | 1.62379E-07 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000219506 | 0.000440227 | 1.31515E-08 | 3.88393E-08 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.0007115 | 0 | 1.17173E-08 | 3.46038E-08 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 1.96519E-06 | 0.00005 | 1.87193E-09 | 5.52822E-09 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0 | 0.2955 | | 0 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0 | 0.469648 | | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 0 | 3.906691677 | | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0 | 0.0018 | | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0 | 0.0021456 | | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 0 | 1.12172959 | | 0 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0 | 0.211451058 | | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0 | 0.000521299 | | 0 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0 | 0.334983061 | | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0 | 0.004850822 | | 0 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $CH_4$ | 0 | 0.00225 | | 0 | 100% |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0 | 0.003576 | | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 0 | 2.1257 | | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0 | 0.02175 | | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0 | 0.034568 | | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | 0 | 107.5693 | | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CH_4$ | 0 | 0.937280723 | | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 0 | 1.489651495 | | 0 | 100% |
| 1.A.2.g Other - Peat | $CO_2$ | 0 | 1.331164465 | | 0 | 100% |
| 1.A.2.g Other - Peat | $CH_4$ | 0 | 0.000575 | | 0 | 100% |
| 1.A.2.g Other - Peat | $N_2O$ | 0 | 0.005811 | | 0 | 100% |
| 1.A.3.b Road Transportation - Biomass | $CH_4$ | 0 | 0.023009615 | | 0 | 100% |
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0 | 0.349076786 | | 0 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0 | 0.0022825 | | 0 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0 | 0.0346276 | | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 0 | 9.442494289 | | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0 | 0.018743571 | | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0 | 0.076423393 | | 0 | 100% |
| 2.D.2 Paraffin wax use | $CO_2$ | 0 | 4.911573333 | | 0 | 100% |
| 2.D.3.d Urea Use | $CO_2$ | 0 | 0.817 | | 0 | 100% |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Trend assessment | Contribution to trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|
| 2.F.1. Refrigeration and air conditioning | HFCs | 0 | 206.3769351 | | 0 | 100% |
| 2.F.2 Foam blowing agents | HFCs | 0 | 0.961490119 | | 0 | 100% |
| 2.F.3. Fire Protection | HFCs | 0 | 0.02767976 | | 0 | 100% |
| 2.F.4. Aerosols | HFCs | 0 | 4.697766137 | | 0 | 100% |
| 2.G.1. Electrical equipment | SF6 | 0 | 8.577903643 | | 0 | 100% |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 0 | 301.0244136 | | 0 | 100% |
| TOTAL | | 26256.43 | 11353.38 | 0.33861408 | 1 | |

### A.1.11 Spreadsheet for the Approach 2 analysis for 2014 – trend assessment with LULUCF

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.E.2 Land converted to Settlements – Carbon stock change – living biomass | $CO_2$ | 115.9029234 | 480.9177105 | 20% | 295% | 2.952512828 | 0.021291627 | 0.062863803 | 0.142540428 | 14% |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass | $CO_2$ | -19117.24262 | -529.091989 | 2% | 3% | 0.032298762 | 0.906170707 | 0.029268192 | 0.066364114 | 21% |
| 4.B.2 Land converted to Cropland – Carbon stock change, forest land converted to cropland | $CO_2$ | 373.3561333 | 21.17573333 | 53% | 161% | 1.693305847 | 0.017089387 | 0.028937559 | 0.065614422 | 27% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – living biomass | $CO_2$ | -65.31052768 | -165.2320183 | 6% | 435% | 4.35209994 | 0.006067551 | 0.02640659 | 0.059875579 | 33% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.5312078 | 55.18201994 | 2% | 50% | 0.50039984 | 0.035016974 | 0.017522488 | 0.039731338 | 37% |
| 4.C.2 Land converted to Grassland – | $CO_2$ | -0.0030613 | -495.2573527 | 10% | 61% | 0.62005174 | 0.027769251 | 0.017218372 | 0.039041771 | 41% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| Mineral soil | | | | | | | | | | |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.621305 | 2.456340066 | 2% | 10% | 0.10198039 | 0.149148925 | 0.015210266 | 0.034488492 | 45% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – living biomass | $CO_2$ | -48.28378427 | -108.185671 | 9% | 389% | 3.895664896 | 0.003702428 | 0.014423418 | 0.032704355 | 48% |
| 4. G. Harvested wood products | $CO_2$ | -166.3561979 | -1817.58 | 15% | 0% | 0.15 | 0.093769333 | 0.0140654 | 0.031892568 | 51% |
| 4.A.1 Forest Land remaining Forest Land – Drained organic soil | $CO_2$ | 4125.54896 | 4583.280676 | 5% | 25% | 0.255514853 | 0.055031493 | 0.014061364 | 0.031883417 | 54% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.784936 | 38.5022 | 2% | 20% | 0.200997512 | 0.066902637 | 0.013447264 | 0.030490976 | 57% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.989353 | 828.0431219 | 2% | 20% | 0.200997512 | 0.057252005 | 0.011507511 | 0.026092686 | 60% |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood | $CO_2$ | 77.31120783 | -3792.439229 | 2% | 5% | 0.049870332 | 0.216429105 | 0.010793391 | 0.024473458 | 63% |
| 4.A.2 Land converted to Forest Land – Carbon stock change, grassland converted to forest land | $CO_2$ | -0.15774 | -341.1744233 | 8% | 50% | 0.504416534 | 0.019122149 | 0.009645528 | 0.021870737 | 65% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $N_2O$ | 567.421657 | 638.8013455 | 6% | 119% | 1.192759666 | 0.008041284 | 0.00959132 | 0.021747823 | 67% |
| 4.C.2 Land converted to Grassland – Drained organic soil | $CO_2$ | 0.0008613 | 275.3924023 | 55% | 19% | 0.582513519 | 0.015441388 | 0.008994817 | 0.020395284 | 69% |
| 3.G. Liming | $CO_2$ | 371.4186667 | 19.68633333 | 2% | 50% | 0.50039984 | 0.017078055 | 0.008545856 | 0.019377287 | 71% |
| 3.D.1. Direct $N_2O$ emissions from managed soils | $N_2O$ | 1962.775641 | 1429.497775 | 2% | 50% | 0.50039984 | 0.015929951 | 0.007971345 | 0.018074613 | 73% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.A.1 Forest land remaining forest land - Controlled burning | $CO_2$ | 256.17754 | 88.88382 | 92% | 6% | 0.921954446 | 0.007556763 | 0.006966991 | 0.015797293 | 74% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 56.12604453 | 149.8529208 | 5% | 119% | 1.18618464 | 0.005654839 | 0.006707683 | 0.015209325 | 76% |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.8184 | 50.2326 | 2% | 20% | 0.200997512 | 0.026839764 | 0.005394726 | 0.012232262 | 77% |
| 4.B.2 Land converted to Cropland – Drained organic soil | $CO_2$ | 12.45566667 | 89.507 | 114% | 18% | 1.153272843 | 0.004408979 | 0.005084756 | 0.011529422 | 78% |
| 4.E.2 Land converted to Settlements – Organic soils | $CO_2$ | 3.765666667 | 166.1761669 | 47% | 18% | 0.504887829 | 0.009133267 | 0.004611275 | 0.010455828 | 79% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.2058686 | 26.17773966 | 2% | 11% | 0.111074685 | 0.037606387 | 0.004177118 | 0.009471399 | 80% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.294341 | 155.5621374 | 2% | 10% | 0.10198039 | 0.040587128 | 0.004139091 | 0.009385176 | 81% |
| 4.E.2 Land converted to Settlements – Mineral soils | $CO_2$ | 1.399566667 | 107.2922807 | 22% | 60% | 0.638992989 | 0.005947435 | 0.00380037 | 0.008617142 | 82% |
| 3.D.2 Indirect $N_2O$ Emissions from managed soils | $N_2O$ | 377.2229002 | 196.0440499 | 2% | 50% | 0.50039984 | 0.007473695 | 0.003739836 | 0.008479885 | 83% |
| 2.A.2. Lime Production | $CO_2$ | 148.8573814 | 0.459881348 | 2% | 50% | 0.50039984 | 0.007261158 | 0.003633482 | 0.008238734 | 84% |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | 147.0542333 | 8.696233333 | 53% | | 0.5337 | 0.006711072 | 0.003581699 | 0.008121318 | 84% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 392.8311633 | 227.8019525 | 7% | 52% | 0.524690385 | 0.006457073 | 0.003387964 | 0.007682034 | 85% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.7039841 | 104.8142275 | 2% | 10% | 0.10198039 | 0.033074715 | 0.003372972 | 0.007648041 | 86% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.28152 | 2.2704 | 2% | 50% | 0.50039984 | 0.004879636 | 0.002441769 | 0.005536585 | 87% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.B.1 Cropland remaining Cropland – Drained organic soil | $CO_2$ | 2761.364974 | 2598.776785 | 13% | 18% | 0.22703524 | 0.01053932 | 0.002392797 | 0.005425544 | 87% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.318679 | 1575.698976 | 2% | 5% | 0.053851648 | 0.041095605 | 0.002213066 | 0.005018013 | 88% |
| 4.C.1 Grassland remaining Grassland – Drained organic soil | $CO_2$ | 924.832656 | 684.0066031 | 26% | 19% | 0.319336437 | 0.006920197 | 0.002209871 | 0.005010769 | 88% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 109.5074001 | 45% | 30% | 0.540832691 | 0.004030959 | 0.002180075 | 0.004943207 | 89% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.1359677 | 1880.266 | 2% | 2% | 0.028284271 | 0.075266324 | 0.002128853 | 0.004827065 | 89% |
| 4.B.2 Land converted to Cropland – Mineral soil | $CO_2$ | 6.935133333 | 48.7498 | 64% | 61% | 0.888776828 | 0.002393941 | 0.002127679 | 0.004824402 | 90% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 16.555 | 2% | 20% | 0.200997512 | 0.009745995 | 0.001958921 | 0.004441752 | 90% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – living biomass | $CO_2$ | -19.17968712 | -42.87716154 | 5% | 122% | 1.222015155 | 0.001465256 | 0.001790565 | 0.004060014 | 90% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.0757089 | 320.5751539 | 2% | 11% | 0.108754816 | 0.016050852 | 0.001745607 | 0.003958075 | 91% |
| 4.E.2 Land converted to Settlements – Carbon stock change – dead organic matter | $CO_2$ | 45.65085251 | 197.4969716 | 20% | | 0.196 | 0.008839059 | 0.001732456 | 0.003928254 | 91% |
| 2.A.1. Cement Production | $CO_2$ | 370.8039966 | 555.775815 | 10% | 5% | 0.111803399 | 0.013010919 | 0.001454665 | 0.003298378 | 91% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.750448 | 613.35806 | 2% | 2% | 0.028284271 | 0.049990547 | 0.001413946 | 0.00320605 | 92% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.184752 | 10.8326905 | 2% | 50% | 0.50039984 | 0.002779372 | 0.001390797 | 0.003153561 | 92% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.6786727 | 10.10088453 | 2% | 10% | 0.10198039 | 0.012977756 | 0.001323477 | 0.003000915 | 92% |
| 3.B.5 Indirect $N_2O$ emissions from Manure Management | $N_2O$ | 137.5202478 | 41.93797066 | 2% | 30% | 0.300665928 | 0.004380474 | 0.001317059 | 0.002986364 | 93% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.5769252 | 20.35027526 | 2% | 10% | 0.10198039 | 0.012251227 | 0.001249385 | 0.002832916 | 93% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change –organic soils | $CO_2$ | 277.2 | 277.2 | 24% | 55% | 0.604211503 | 0.001973145 | 0.001192197 | 0.002703244 | 93% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.4292 | 118.6284 | 2% | 20% | 0.200997512 | 0.005847321 | 0.001175297 | 0.002664925 | 94% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – living biomass | $CO_2$ | -6.124066667 | -8.288426667 | 3% | 701% | 7.007048237 | 0.000164949 | 0.001155805 | 0.002620729 | 94% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 120.6657672 | 42.94734024 | 25% | 20% | 0.320156212 | 0.003498808 | 0.001120165 | 0.002539917 | 94% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.168965 | 91.04761992 | 2% | 5% | 0.053851648 | 0.020554294 | 0.001106883 | 0.002509799 | 94% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.03 | 3.9825 | 2% | 50% | 0.50039984 | 0.002127888 | 0.001064795 | 0.002414368 | 95% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 103.071464 | 2.2704 | 2% | 20% | 0.200997512 | 0.004918305 | 0.000988567 | 0.002241525 | 95% |
| 4.E.2 Lands converted to settlements, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0.910565999 | 40.47931849 | 20% | 38% | 0.424817149 | 0.002225127 | 0.000945272 | 0.002143356 | 95% |
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 109.190125 | 32% | 0% | 0.322375 | 0.002553886 | 0.000823309 | 0.001866811 | 95% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.20060747 | 24.62371876 | 2% | 50% | 0.50039984 | 0.001615256 | 0.000808274 | 0.001832719 | 95% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.37994 | 213.786 | 2% | 5% | 0.053851648 | 0.014025269 | 0.000755284 | 0.001712567 | 96% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 137.025 | 138.525 | 64% | 30% | 0.706823882 | 0.001059467 | 0.000748857 | 0.001697994 | 96% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.9110639 | 157.1324033 | 2% | 10% | 0.10198039 | 0.007339463 | 0.000748481 | 0.001697143 | 96% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.A.1 Forest land remaining forest land - Controlled burning | $CH_4$ | 25.2045 | 8.745 | 92% | 36% | 0.987927123 | 0.000743486 | 0.00073451 | 0.001665464 | 96% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.826737 | 0 | 2% | 10% | 0.10198039 | 0.006991729 | 0.000713019 | 0.001616734 | 96% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.59606386 | 0.01036233 | 5% | 25% | 0.254950976 | 0.002574129 | 0.000656277 | 0.001488074 | 96% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.37841625 | 20.64571937 | 25% | 20% | 0.320156212 | 0.002042819 | 0.000654021 | 0.00148296 | 96% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.4643123 | 0.705374886 | 2% | 5% | 0.053851648 | 0.011438069 | 0.000615959 | 0.001396655 | 97% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.4838285 | 73.41324777 | 2% | 5% | 0.053851648 | 0.011278448 | 0.000607363 | 0.001377164 | 97% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | 61.3521 | 0 | 2% | 20% | 0.200997512 | 0.00300334 | 0.000603664 | 0.001368777 | 97% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 40.75322335 | 5.647103039 | 25% | 20% | 0.320156212 | 0.001678336 | 0.00053733 | 0.001218368 | 97% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455344 | 17.42704 | 5% | 50% | 0.502493781 | 0.000954855 | 0.000479809 | 0.001087942 | 97% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.9670107 | 70.59473241 | 25% | 20% | 0.320156212 | 0.001473823 | 0.000471853 | 0.001069903 | 97% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.25228881 | 0 | 2% | 10% | 0.10198039 | 0.004564935 | 0.000465534 | 0.001055574 | 97% |
| 4.C. Grassland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 69.98791354 | 72.89522859 | 24% | 58% | 0.62938462 | 0.000661198 | 0.000416148 | 0.000943594 | 97% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.593827044 | 19.44722022 | 2% | 50% | 0.50039984 | 0.000816586 | 0.00040862 | 0.000926524 | 98% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687214 | 16.53660558 | 140% | 30% | 1.431782106 | 0.000281283 | 0.000402736 | 0.000913184 | 98% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.95737306 | 165.2425801 | 2% | 5% | 0.053851648 | 0.007456102 | 0.000401523 | 0.000910434 | 98% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 4.B.2 Land converted to cropland, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0.590489444 | 4.882747284 | 64% | 151% | 1.639033023 | 0.000244873 | 0.000401355 | 0.000910051 | 98% |
| 4.B. Cropland remaining cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 125.0975756 | 119.0448062 | 13% | 71% | 0.722349638 | 0.000551078 | 0.000398071 | 0.000902605 | 98% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.4154681 | 5.263181843 | 2% | 5% | 0.053851648 | 0.007019154 | 0.000377993 | 0.00085708 | 98% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, dead wood | $CO_2$ | -1.612112333 | -83.797142 | 8% | | 0.0802 | 0.004619643 | 0.000370495 | 0.000840079 | 98% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.54125 | 13.1025 | 2% | 20% | 0.200997512 | 0.001837361 | 0.000369305 | 0.00083738 | 98% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.83865681 | 0 | 2% | 10% | 0.10198039 | 0.003614588 | 0.000368617 | 0.00083582 | 98% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.519712 | 13.38625669 | 5% | 50% | 0.502493781 | 0.000725135 | 0.000364376 | 0.000826203 | 98% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.54499789 | 1.136164465 | 2% | 11% | 0.110909091 | 0.00319384 | 0.000354226 | 0.000803189 | 98% |
| 2.D.1 Lubricant Use | $CO_2$ | 23.25102433 | 8.297813333 | 2% | 50% | 0.50039984 | 0.000672933 | 0.000336735 | 0.00076353 | 98% |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, litter | $CO_2$ | -1.3821621 | -71.8444518 | 8% | | 0.0802 | 0.003960705 | 0.000317649 | 0.000720252 | 99% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.2865 | 10.965 | 5% | 50% | 0.502493781 | 0.00060079 | 0.000301893 | 0.000684527 | 99% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.92 | 18.5 | 2% | 50% | 0.50039984 | 0.00057421 | 0.000287335 | 0.000651516 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 8.434081116 | 5% | 50% | 0.502493781 | 0.000456897 | 0.000229588 | 0.000520579 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.15516309 | 2.207274532 | 2% | 30% | 0.300665928 | 0.000716025 | 0.000215284 | 0.000488146 | 99% |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.27150449 | 0 | 2% | 10% | 0.10198039 | 0.002069297 | 0.000211028 | 0.000478494 | 99% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263264 | 5.4868 | 2% | 20% | 0.200997512 | 0.001026957 | 0.000206416 | 0.000468037 | 99% |
| 4.A.1 Forest land remaining forest land - wildfires | $CH_4$ | 2.525 | 9.198 | 37% | 36% | 0.51623638 | 0.000392133 | 0.000202433 | 0.000459007 | 99% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344325 | 26.126175 | 10% | 0% | 0.1 | 0.001978621 | 0.000197862 | 0.000448642 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 0.18 | 2% | 50% | 0.50039984 | 0.000386863 | 0.000193586 | 0.000438947 | 99% |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 13.07410741 | 4.606850327 | 2% | 50% | 0.50039984 | 0.000381701 | 0.000191003 | 0.00043309 | 99% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.98598703 | 11.52240459 | 25% | 30% | 0.390512484 | 0.000479153 | 0.000187115 | 0.000424274 | 99% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.2220665 | 93.81485986 | 2% | 5% | 0.053851648 | 0.00326835 | 0.000176006 | 0.000399085 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.1626684 | 0.0057514 | 2% | 50% | 0.50039984 | 0.000350308 | 0.000175294 | 0.00039747 | 99% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CO_2$ | 1016.928 | 899.740705 | 24% | | 0.2423 | 0.000667854 | 0.000161821 | 0.000366921 | 99% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 334.0088098 | 238.7965288 | 2% | 5% | 0.053851648 | 0.002961097 | 0.00015946 | 0.000361567 | 99% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.66618252 | 0.181929 | 2% | 50% | 0.50039984 | 0.000316126 | 0.000158189 | 0.000358686 | 99% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CH_4$ | 28.53444375 | 28.53444375 | 24% | 71% | 0.751152641 | 0.000203112 | 0.000152568 | 0.00034594 | 99% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.15 | 2.625286653 | 5% | 50% | 0.502493781 | 0.000300714 | 0.000151107 | 0.000342627 | 99% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.42474185 | 101.6540154 | 10% | 10% | 0.141421356 | 0.000979572 | 0.000138532 | 0.000314115 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.26924002 | 33.54418198 | 2% | 50% | 0.50039984 | 0.000237294 | 0.000118742 | 0.000269242 | 99% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.6011945 | 230.7118474 | 2% | 5% | 0.053851648 | 0.002186131 | 0.000117727 | 0.000266939 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.286318275 | 0.590724755 | 2% | 50% | 0.50039984 | 0.000225656 | 0.000112918 | 0.000256037 | 99% |
| 5.B.1. Composting | $CH_4$ | 23.90918253 | 22.4652 | 29% | 100% | 1.041201229 | 8.92235E-05 | 9.28997E-05 | 0.000210645 | 99% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.72829 | 0.10175 | 2% | 50% | 0.50039984 | 0.000176804 | 8.84727E-05 | 0.000200607 | 100% |
| 4.A.1 Forest land remaining forest land - Controlled burning | $N_2O$ | 2.95616 | 1.02512 | 92% | | 0.92 | 8.72323E-05 | 8.02538E-05 | 0.000181971 | 100% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.163685304 | 2.934347457 | 2% | 50% | 0.50039984 | 0.000156518 | 7.83216E-05 | 0.00017759 | 100% |
| 1.A.4.b Residential - Peat | $CH_4$ | 3.1875 | 0 | 2% | 50% | 0.50039984 | 0.000156036 | 7.80805E-05 | 0.000177043 | 100% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.090525 | 13.021775 | 2% | 50% | 0.50039984 | 0.000155437 | 7.77809E-05 | 0.000176364 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.54739345 | 0.397748377 | 2% | 10% | 0.10198039 | 0.000738782 | 7.53413E-05 | 0.000170832 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.0225 | 0 | 2% | 50% | 0.50039984 | 0.000147959 | 7.40387E-05 | 0.000167879 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.00505 | 0.002425 | 2% | 50% | 0.50039984 | 0.000146969 | 7.35432E-05 | 0.000166755 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 0.649625 | 2% | 50% | 0.50039984 | 0.000134664 | 6.73859E-05 | 0.000152794 | 100% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.4845375 | 7.840283798 | 25% | 30% | 0.390512484 | 0.00017154 | 6.69884E-05 | 0.000151893 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.862588 | 0.237357 | 2% | 50% | 0.50039984 | 0.000126822 | 6.34618E-05 | 0.000143896 | 100% |
| 3.H. Urea Application | $CO_2$ | 7.7088 | 4.726333333 | 20% | 50% | 0.538516481 | 0.000112357 | 6.05059E-05 | 0.000137194 | 100% |
| 5.B.1. Composting | $N_2O$ | 17.09984734 | 16.06711104 | 29% | 90% | 0.945568612 | 6.38127E-05 | 6.03393E-05 | 0.000136816 | 100% |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – dead organic matter | $CO_2$ | -13.80988549 | -29.46614791 | 6% | | 0.059 | 0.000976157 | 5.75933E-05 | 0.00013059 | 100% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.26531 | 0.173975 | 2% | 50% | 0.50039984 | 0.000101138 | 5.06093E-05 | 0.000114754 | 100% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 8.94447 | 10.597476 | 10% | 30% | 0.316227766 | 0.000156353 | 4.94432E-05 | 0.00011211 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.411706848 | 0.369840648 | 2% | 50% | 0.50039984 | 9.73219E-05 | 4.86999E-05 | 0.000110424 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.6165255 | 0 | 2% | 5% | 0.053851648 | 0.000862373 | 4.64402E-05 | 0.000105301 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.149772 | 0.252487056 | 2% | 50% | 0.50039984 | 9.10796E-05 | 4.55762E-05 | 0.000103342 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.87891384 | 0.0437464 | 2% | 50% | 0.50039984 | 8.95247E-05 | 4.47981E-05 | 0.000101577 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008344 | 1.509107769 | 5% | 50% | 0.502493781 | 8.42082E-05 | 4.23141E-05 | 9.5945E-05 | 100% |
| 2.D.3. Solvent Use | $CO_2$ | 41.0641984 | 32.19721064 | 2% | 20% | 0.200997512 | 0.000204878 | 4.11799E-05 | 9.33733E-05 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.341428614 | 0.115643072 | 23% | 30% | 0.378021163 | 0.000108135 | 4.08772E-05 | 9.26869E-05 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.1006644 | 1.5198 | 2% | 50% | 0.50039984 | 8.02884E-05 | 4.01763E-05 | 9.10977E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774375 | 0.127125 | 2% | 50% | 0.50039984 | 7.97321E-05 | 3.9898E-05 | 9.04666E-05 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.8332289 | 12.58 | 2% | 5% | 0.053851648 | 0.00066458 | 3.57887E-05 | 8.11491E-05 | 100% |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $N_2O$ | 3.793114158 | 3.793114158 | 24% | 112% | 1.145909809 | 2.69999E-05 | 3.09394E-05 | 7.01535E-05 | 100% |
| 2.A.3. Glass production | $CO_2$ | 0.355752064 | 0.942744575 | 2% | 86% | 0.860232527 | 3.54453E-05 | 3.04912E-05 | 6.91373E-05 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.0786 | 0 | 2% | 20% | 0.200997512 | 0.000150705 | 3.02914E-05 | 6.86841E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.00525 | 0.949410006 | 5% | 50% | 0.502493781 | 5.2977E-05 | 2.66206E-05 | 6.03609E-05 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692316 | 0 | 2% | 20% | 0.200997512 | 0.000131796 | 2.64906E-05 | 6.00661E-05 | 100% |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – dead organic matter | $CO_2$ | -6.10842148 | -10.61212032 | 9% | | 0.0867 | 0.000296006 | 2.56637E-05 | 5.81911E-05 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.997704 | 0 | 2% | 50% | 0.50039984 | 4.88401E-05 | 2.44396E-05 | 5.54155E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.45424 | 0.431444174 | 5% | 50% | 0.502493781 | 4.69974E-05 | 2.36159E-05 | 5.35478E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030335 | 0.078225 | 2% | 50% | 0.50039984 | 4.60514E-05 | 2.30441E-05 | 5.22513E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 34.97326278 | 5% | 50% | 0.502493781 | 4.52166E-05 | 2.2721E-05 | 5.15188E-05 | 100% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.124565463 | 0.863788568 | 2% | 50% | 0.50039984 | 4.23354E-05 | 2.11846E-05 | 4.8035E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.78871 | 0.02035 | 2% | 50% | 0.50039984 | 3.74683E-05 | 1.87491E-05 | 4.25127E-05 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.69904433 | 45.0354735 | 2% | 5% | 0.053851648 | 0.000337037 | 1.815E-05 | 4.11542E-05 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.7015 | 0 | 2% | 50% | 0.50039984 | 3.43402E-05 | 1.71838E-05 | 3.89634E-05 | 100% |
| 4.A.1 Forest land remaining forest land - wildfires | $N_2O$ | 0.295616 | 1.078462 | 37% | | 0.37 | 4.59989E-05 | 1.70196E-05 | 3.85911E-05 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $N_2O$ | 0.053992802 | 0.663123844 | 10% | 48% | 0.490306027 | 3.45387E-05 | 1.69345E-05 | 3.83982E-05 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.65129688 | 0.0069732 | 2% | 50% | 0.50039984 | 3.14916E-05 | 1.57584E-05 | 3.57314E-05 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.62775 | 0 | 2% | 50% | 0.50039984 | 3.07299E-05 | 1.53773E-05 | 3.48671E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.615519 | 0 | 2% | 50% | 0.50039984 | 3.01312E-05 | 1.50777E-05 | 3.41878E-05 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868375 | 1.276125 | 2% | 50% | 0.50039984 | 2.9044E-05 | 1.45336E-05 | 3.29542E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.64092648 | 0.04917 | 2% | 50% | 0.50039984 | 2.8618E-05 | 1.43204E-05 | 3.24708E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.07599 | 0.560538 | 2% | 50% | 0.50039984 | 2.77098E-05 | 1.3866E-05 | 3.14404E-05 | 100% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.824479542 | 2.221483039 | 25% | 30% | 0.390512484 | 3.52471E-05 | 1.37644E-05 | 3.12102E-05 | 100% |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – dead organic matter | $CO_2$ | -4.284491677 | -8.55723594 | 5% | | 0.0498 | 0.000270073 | 1.34496E-05 | 3.04964E-05 | 100% |
| 4.C.1 Grassland remaining Grassland, wildfires | $CH_4$ | 0.049609865 | 0.609294045 | 10% | 39% | 0.402616443 | 3.1735E-05 | 1.2777E-05 | 2.89712E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.4832964 | 0.010728 | 2% | 50% | 0.50039984 | 2.30571E-05 | 1.15377E-05 | 2.61612E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.47777148 | 0.010728 | 2% | 50% | 0.50039984 | 2.27866E-05 | 1.14024E-05 | 2.58544E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.4367772 | 0.865392 | 2% | 50% | 0.50039984 | 2.18108E-05 | 1.09141E-05 | 2.47472E-05 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.42449305 | 17.14603569 | 2% | 5% | 0.053851648 | 0.000185299 | 9.97864E-06 | 2.2626E-05 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.745009038 | 0.299750179 | 2% | 50% | 0.50039984 | 1.96629E-05 | 9.8393E-06 | 2.23101E-05 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.4629 | 4.554798669 | 10% | 5% | 0.111803399 | 8.58728E-05 | 9.60087E-06 | 2.17695E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423011 | 0.0303066 | 2% | 50% | 0.50039984 | 1.90081E-05 | 9.51167E-06 | 2.15672E-05 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.054819072 | 3.13427 | 2% | 5% | 0.053851648 | 0.000173057 | 9.31941E-06 | 2.11313E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.20535 | 0.726 | 2% | 50% | 0.50039984 | 1.82976E-05 | 9.15613E-06 | 2.07611E-05 | 100% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.847024532 | 4.3807102 | 43% | 100% | 1.08853112 | 8.35519E-06 | 9.09488E-06 | 2.06222E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.271776 | 0.556962 | 5% | 50% | 0.502493781 | 1.79251E-05 | 9.00725E-06 | 2.04235E-05 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.3177723 | 0 | 2% | 50% | 0.50039984 | 1.55558E-05 | 7.7841E-06 | 1.765E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.2955862 | 0.004619 | 2% | 50% | 0.50039984 | 1.42107E-05 | 7.11103E-06 | 1.61239E-05 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.27267 | 0 | 2% | 50% | 0.50039984 | 1.33479E-05 | 6.67928E-06 | 1.51449E-05 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.108041461 | 1.356526416 | 2% | 30% | 0.300665928 | 2.18199E-05 | 6.5605E-06 | 1.48756E-05 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273195 | 0.004725 | 2% | 50% | 0.50039984 | 1.31087E-05 | 6.55957E-06 | 1.48735E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.268845 | 0.020625 | 2% | 50% | 0.50039984 | 1.20042E-05 | 6.00689E-06 | 1.36203E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CH_4$ | 0.2325 | 0 | 2% | 50% | 0.50039984 | 1.13815E-05 | 5.69528E-06 | 1.29138E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.3505 | 5% | 50% | 0.502493781 | 1.12819E-05 | 5.66908E-06 | 1.28543E-05 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.28480456 | 0.0500044 | 2% | 50% | 0.50039984 | 1.11381E-05 | 5.57351E-06 | 1.26377E-05 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.2179572 | 0 | 2% | 50% | 0.50039984 | 1.06696E-05 | 5.33904E-06 | 1.2106E-05 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.78185 | 0.439375 | 25% | 30% | 0.390512484 | 1.36375E-05 | 5.32561E-06 | 1.20755E-05 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.810707594 | 0.56263867 | 43% | 40% | 0.587281874 | 8.13867E-06 | 4.77969E-06 | 1.08377E-05 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.23893 | 0.04195 | 2% | 50% | 0.50039984 | 9.34406E-06 | 4.67577E-06 | 1.06021E-05 | 100% |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.1860712 | 0 | 2% | 50% | 0.50039984 | 9.10865E-06 | 4.55797E-06 | 1.0335E-05 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.168 | 0.00275 | 2% | 50% | 0.50039984 | 8.06983E-06 | 4.03814E-06 | 9.15628E-06 | 100% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 6.219856 | 5.564080248 | 5% | 50% | 0.502493781 | 7.50395E-06 | 3.77069E-06 | 8.54984E-06 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.76125 | 0.550125 | 2% | 50% | 0.50039984 | 6.41924E-06 | 3.21219E-06 | 7.28347E-06 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127395 | 0.0003874 | 2% | 50% | 0.50039984 | 6.21458E-06 | 3.10978E-06 | 7.05126E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.1708732 | 0.0403194 | 2% | 50% | 0.50039984 | 6.10394E-06 | 3.05441E-06 | 6.92572E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.7792529 | 21.16428627 | 2% | 10% | 0.10198039 | 2.63117E-05 | 2.68327E-06 | 6.08419E-06 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.5005 | 0.5315 | 2% | 50% | 0.50039984 | 5.30081E-06 | 2.65253E-06 | 6.01447E-06 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.106875 | 0.000325 | 2% | 50% | 0.50039984 | 5.21358E-06 | 2.60887E-06 | 5.91549E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.14335 | 0.033825 | 2% | 50% | 0.50039984 | 5.12075E-06 | 2.56242E-06 | 5.81017E-06 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.12419448 | 0.025926 | 2% | 50% | 0.50039984 | 4.62595E-06 | 2.31482E-06 | 5.24874E-06 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.172771761 | 0.3465 | 20% | 5% | 0.206155281 | 1.09709E-05 | 2.2617E-06 | 5.12829E-06 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091425 | 0 | 2% | 50% | 0.50039984 | 4.47548E-06 | 2.23953E-06 | 5.07802E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.08118414 | 0.0028906 | 2% | 50% | 0.50039984 | 3.81209E-06 | 1.90757E-06 | 4.32532E-06 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.001463305 | 0.054450618 | 20% | 60% | 0.632455532 | 2.98145E-06 | 1.88563E-06 | 4.27558E-06 | 100% |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.002972338 | 0.049156808 | 20% | 60% | 0.632455532 | 2.61075E-06 | 1.65118E-06 | 3.74397E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.0681075 | 0.002425 | 2% | 50% | 0.50039984 | 3.19806E-06 | 1.60031E-06 | 3.62862E-06 | 100% |
| 2.G.3. $N_2O$ from product uses | $N_2O$ | 1.30226 | 2.01448 | 2% | 2% | 0.028284271 | 4.92043E-05 | 1.39171E-06 | 3.15562E-06 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.4500694 | 0.344594088 | 2% | 50% | 0.50039984 | 2.71042E-06 | 1.35629E-06 | 3.07532E-06 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.057625 | 0.004375 | 2% | 50% | 0.50039984 | 2.57558E-06 | 1.28882E-06 | 2.92233E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050064 | 0 | 2% | 50% | 0.50039984 | 2.45076E-06 | 1.22636E-06 | 2.78071E-06 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.06875 | 1.15638E-05 | 10% | 25% | 0.26925824 | 3.36484E-06 | 9.0601E-07 | 2.05433E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.0362964 | 0.0004768 | 2% | 50% | 0.50039984 | 1.75007E-06 | 8.75733E-07 | 1.98568E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.09466268 | 0.0515242 | 2% | 50% | 0.50039984 | 1.74498E-06 | 8.73189E-07 | 1.97991E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034425 | 0 | 2% | 50% | 0.50039984 | 1.68519E-06 | 8.43269E-07 | 1.91207E-06 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.011005031 | 0.28 | 2% | 5% | 0.053851648 | 1.51611E-05 | 8.16448E-07 | 1.85125E-06 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.000453151 | 0.029353 | 2% | 50% | 0.50039984 | 1.62366E-06 | 8.12479E-07 | 1.84225E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.00425 | 0.03135 | 2% | 50% | 0.50039984 | 1.54977E-06 | 7.75503E-07 | 1.75841E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CH_4$ | 0.0315 | 0 | 2% | 50% | 0.50039984 | 1.542E-06 | 7.71619E-07 | 1.74961E-06 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181482 | 0.1311498 | 2% | 50% | 0.50039984 | 1.53035E-06 | 7.65786E-07 | 1.73638E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079415 | 0.043225 | 2% | 50% | 0.50039984 | 1.46391E-06 | 7.32541E-07 | 1.661E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.026721 | 0.0006 | 2% | 50% | 0.50039984 | 1.27442E-06 | 6.37719E-07 | 1.44599E-06 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.1193192 | 0.1267096 | 2% | 50% | 0.50039984 | 1.26371E-06 | 6.32362E-07 | 1.43385E-06 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001126 | 0.017 | 2% | 50% | 0.50039984 | 8.9808E-07 | 4.49399E-07 | 1.01899E-06 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.0177725 | 0 | 2% | 50% | 0.50039984 | 8.70009E-07 | 4.35352E-07 | 9.87139E-07 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015225 | 0.00025 | 2% | 50% | 0.50039984 | 7.31284E-07 | 3.65935E-07 | 8.29738E-07 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.02384 | 0.032918912 | 10% | 50% | 0.509901951 | 6.78757E-07 | 3.46099E-07 | 7.84762E-07 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.013857 | 0 | 2% | 50% | 0.50039984 | 6.78335E-07 | 3.39439E-07 | 7.6966E-07 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.01272162 | 0 | 2% | 50% | 0.50039984 | 6.22755E-07 | 3.11627E-07 | 7.06597E-07 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.02475 | 0.014988474 | 10% | 50% | 0.509901951 | 3.71161E-07 | 1.89256E-07 | 4.29128E-07 | 100% |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – dead organic matter | $CO_2$ | -1.368033333 | -1.2914 | 3% | | 0.026 | 5.44095E-06 | 1.41465E-07 | 3.20764E-07 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.006946 | 0.00145 | 2% | 50% | 0.50039984 | 2.58722E-07 | 1.29464E-07 | 2.93554E-07 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.05379496 | 0.0511368 | 2% | 50% | 0.50039984 | 2.33875E-07 | 1.17031E-07 | 2.65361E-07 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.00295205 | 0.005924494 | 20% | 50% | 0.538516481 | 1.8768E-07 | 1.01069E-07 | 2.29168E-07 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.024287 | 0.024734 | 2% | 50% | 0.50039984 | 1.97942E-07 | 9.90499E-08 | 2.24591E-07 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020375 | 0.02075 | 2% | 50% | 0.50039984 | 1.66058E-07 | 8.30956E-08 | 1.88415E-07 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 9.36998E-05 | 0.002384 | 2% | 50% | 0.50039984 | 1.29086E-07 | 6.45944E-08 | 1.46464E-07 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.008686 | 0.011105 | 32% | 0% | 0.322375 | 1.97463E-07 | 6.36571E-08 | 1.44339E-07 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.000009504 | 0.0021375 | 2% | 50% | 0.50039984 | 1.19386E-07 | 5.97406E-08 | 1.35459E-07 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.01272758 | 0.0094168 | 2% | 50% | 0.50039984 | 9.50411E-08 | 4.75585E-08 | 1.07837E-07 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.0106775 | 0.0079 | 2% | 50% | 0.50039984 | 7.97324E-08 | 3.98981E-08 | 9.04669E-08 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.02314 | 0.02145 | 2% | 50% | 0.50039984 | 6.9954E-08 | 3.5005E-08 | 7.9372E-08 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.0007115 | 0 | 2% | 50% | 0.50039984 | 3.48297E-08 | 1.74288E-08 | 3.95189E-08 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000219506 | 0.000440227 | 20% | 50% | 0.538516481 | 1.39385E-08 | 7.50609E-09 | 1.70197E-08 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 1.96519E-06 | 0.00005 | 2% | 50% | 0.50039984 | 2.70733E-09 | 1.35475E-09 | 3.07182E-09 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.002806 | 0.002657 | 10% | 0% | 0.1 | 1.16189E-08 | 1.16189E-09 | 2.63453E-09 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0 | 0.2955 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0 | 0.469648 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 0 | 3.906691677 | 2% | 5% | 0.053851648 | | 0 | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0 | 0.0018 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0 | 0.0021456 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 0 | 1.12172959 | 2% | 11% | 0.110909091 | | 0 | 0 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0 | 0.211451058 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0 | 0.000521299 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0 | 0.334983061 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0 | 0.004850822 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass | $CH_4$ | 0 | 0.00225 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| Fuels | | | | | | | | | | |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0 | 0.003576 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 0 | 2.1257 | 2% | 20% | 0.200997512 | | 0 | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0 | 0.02175 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0 | 0.034568 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | 0 | 107.5693 | 2% | 2% | 0.028284271 | | 0 | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CH_4$ | 0 | 0.937280723 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 0 | 1.489651495 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.g Other - Peat | $CO_2$ | 0 | 1.331164465 | 2% | 10% | 0.10198039 | | 0 | 0 | 100% |
| 1.A.2.g Other - Peat | $CH_4$ | 0 | 0.000575 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.g Other - Peat | $N_2O$ | 0 | 0.005811 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.3.b Road Transportation - Biomass | $CH_4$ | 0 | 0.023009615 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0 | 0.349076786 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0 | 0.0022825 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0 | 0.0346276 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 0 | 9.442494289 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0 | 0.018743571 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0 | 0.076423393 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.D.2 Paraffin wax use | $CO_2$ | 0 | 4.911573333 | 2% | 100% | 1.00019998 | | 0 | 0 | 100% |
| 2.D.3.d Urea Use | $CO_2$ | 0 | 0.817 | 20% | 10% | 0.223606798 | | 0 | 0 | 100% |
| 2.F.1. Refrigeration and air conditioning | HFCs | 0 | 206.3769351 | 50% | 50% | 0.707106781 | | 0 | 0 | 100% |
| 2.F.2 Foam blowing agents | HFCs | 0 | 0.961490119 | 50% | 50% | 0.707106781 | | 0 | 0 | 100% |
| 2.F.3. Fire Protection | HFCs | 0 | 0.02767976 | 50% | 50% | 0.707106781 | | 0 | 0 | 100% |
| 2.F.4. Aerosols | HFCs | 0 | 4.697766137 | 50% | 50% | 0.707106781 | | 0 | 0 | 100% |
| 2.G.1. Electrical equipment | SF6 | 0 | 8.577903643 | 2% | 30% | 0.300665928 | | 0 | 0 | 100% |
| 4.A.2 Land converted to Forest Land – grassland converted to forest land, Drained organic soil | $CO_2$ | 0 | 61.24812203 | 44% | 25% | 0.501982161 | | 0 | 0 | 100% |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CO_2$ | 0 | 22.06783674 | 5% | 242% | 2.420575931 | | 0 | 0 | 100% |
| 4.B.2 Wetlands converted to cropland, organic soil | $CO_2$ | 0 | 3.8236 | 114% | 18% | 1.153209092 | | 0 | 0 | 100% |
| 4.B.2 Settlements converted to cropland, mineral soils | $CO_2$ | 0 | 5.310433333 | 64% | 60% | 0.880556784 | | 0 | 0 | 100% |
| 4.E.1 Settlements remaining Settlements – Drained organic soils | $CO_2$ | 0 | 19.43012935 | 9% | 18% | 0.202860666 | | 0 | 0 | 100% |
| 4.E.2 Settlements remaining Settlements, Direct nitrous oxide ($N_2O$) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0 | 4.083489381 | 9% | 38% | 0.386743455 | | 0 | 0 | 100% |

| IPCC category/Group | Gas | 1990 emissions or removals (kt $CO_2$ eq) | 2014 emissions or removals (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 0 | 301.0244136 | 7% | 52% | 0.524690385 | | 0 | 0 | 100% |
| TOTAL | | 17834.80 | 15573.52 | | | 162.446478 | 2.386613709 | 0.441024373 | 1 | |

## A.1.12 Spreadsheet for the Approach 2 analysis for 2014 – trend assessment without LULUCF

| IPCC category/Group | Gas | 1990 emissions (kt $CO_2$ eq) | 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.D.1. Direct $N_2O$ emissions from managed soils | $N_2O$ | 1962.77564 | 1429.497775 | 2% | 50% | 0.50039984 | 0.022119758 | 0.011068724 | 0.191920686 | 19% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.531208 | 55.18201994 | 2% | 50% | 0.50039984 | 0.010719577 | 0.005364075 | 0.093007736 | 28% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.6213 | 2.456340066 | 2% | 10% | 0.10198039 | 0.05012911 | 0.005112186 | 0.088640237 | 37% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.78494 | 38.5022 | 2% | 20% | 0.200997512 | 0.021767108 | 0.004375135 | 0.075860494 | 45% |
| 3.G. Liming | $CO_2$ | 371.418667 | 19.68633333 | 2% | 50% | 0.50039984 | 0.005366933 | 0.002685613 | 0.046565858 | 50% |
| 5.D.2 Industrial Wastewater | $CH_4$ | 137.025 | 138.525 | 64% | 30% | 0.706823882 | 0.003019255 | 0.002134081 | 0.037002851 | 53% |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.135968 | 1880.266 | 2% | 2% | 0.028284271 | 0.061464797 | 0.001738487 | 0.03014364 | 56% |
| 2.A.1. Cement Production | $CO_2$ | 370.803997 | 555.775815 | 10% | 5% | 0.111803399 | 0.015060641 | 0.001683831 | 0.029195956 | 59% |

| IPCC category/Group | Gas | 1990 emissions (kt $CO_2$ eq) | 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.8184 | 50.2326 | 2% | 20% | 0.200997512 | 0.008063761 | 0.001620796 | 0.028102994 | 62% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.205869 | 26.17773966 | 2% | 11% | 0.111074685 | 0.012148244 | 0.001349362 | 0.023396604 | 64% |
| 2.A.2. Lime Production | $CO_2$ | 148.857381 | 0.459881348 | 2% | 50% | 0.50039984 | 0.002433941 | 0.001217944 | 0.02111794 | 66% |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 392.831163 | 227.8019525 | 7% | 52% | 0.524690385 | 0.002206706 | 0.001157838 | 0.020075754 | 69% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.29434 | 155.5621374 | 2% | 10% | 0.10198039 | 0.010663894 | 0.001087508 | 0.018856311 | 70% |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.703984 | 104.8142275 | 2% | 10% | 0.10198039 | 0.0091121 | 0.000929255 | 0.016112368 | 72% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.31868 | 1575.698976 | 2% | 5% | 0.053851648 | 0.016463977 | 0.000886612 | 0.015372978 | 74% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.4292 | 118.6284 | 2% | 20% | 0.200997512 | 0.004247505 | 0.000853738 | 0.014802971 | 75% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.28152 | 2.2704 | 2% | 50% | 0.50039984 | 0.001597952 | 0.000799615 | 0.01386453 | 76% |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.98935 | 828.0431219 | 2% | 20% | 0.200997512 | 0.00334332 | 0.000671999 | 0.011651796 | 78% |
| 3.D.2 Indirect $N_2O$ Emissions from managed soils | $N_2O$ | 377.2229 | 196.0440499 | 2% | 50% | 0.50039984 | 0.001254222 | 0.000627613 | 0.010882181 | 79% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 16.555 | 2% | 20% | 0.200997512 | 0.002960492 | 0.000595051 | 0.010317603 | 80% |
| 5.B.1. Composting | $CH_4$ | 23.9091825 | 22.4652 | 29% | 100% | 1.041201229 | 0.000461859 | 0.000480888 | 0.008338128 | 81% |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.678673 | 10.10088453 | 2% | 10% | 0.10198039 | 0.004171779 | 0.00042544 | 0.007376702 | 81% |
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 109.5074001 | 45% | 30% | 0.540832691 | 0.000748947 | 0.000405055 | 0.007023255 | 82% |

| IPCC category/Group | Gas | 1990 emissions (kt $CO_2$ eq) | 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 109.190125 | 32% | 0% | 0.322375 | 0.001239762 | 0.000399668 | 0.006929851 | 83% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.576925 | 20.35027526 | 2% | 10% | 0.10198039 | 0.003730341 | 0.000380422 | 0.006596133 | 83% |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.184752 | 10.8326905 | 2% | 50% | 0.50039984 | 0.000726796 | 0.000363688 | 0.006305997 | 84% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 34.97326278 | 5% | 50% | 0.502493781 | 0.000687494 | 0.000345461 | 0.005989958 | 85% |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455344 | 17.42704 | 5% | 50% | 0.502493781 | 0.000656226 | 0.000329749 | 0.005717526 | 85% |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.59382704 | 19.44722022 | 2% | 50% | 0.50039984 | 0.000648543 | 0.000324531 | 0.005627043 | 86% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 103.071464 | 2.2704 | 2% | 20% | 0.200997512 | 0.001610961 | 0.000323799 | 0.005614357 | 86% |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.4247418 | 101.6540154 | 10% | 10% | 0.141421356 | 0.002283615 | 0.000322952 | 0.005599666 | 87% |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.03 | 3.9825 | 2% | 50% | 0.50039984 | 0.000639305 | 0.000319908 | 0.005546885 | 87% |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687214 | 16.53660558 | 140% | 30% | 1.431782106 | 0.00022325 | 0.000319646 | 0.005542343 | 88% |
| 5.B.1. Composting | $N_2O$ | 17.0998473 | 16.06711104 | 29% | 90% | 0.945568612 | 0.000330322 | 0.000312342 | 0.005415698 | 88% |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.9573731 | 165.2425801 | 2% | 5% | 0.053851648 | 0.005684781 | 0.000306135 | 0.005308074 | 89% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.26924 | 33.54418198 | 2% | 50% | 0.50039984 | 0.000564981 | 0.000282717 | 0.004902025 | 89% |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.601194 | 230.7118474 | 2% | 5% | 0.053851648 | 0.005170368 | 0.000278433 | 0.00482775 | 90% |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.168965 | 91.04761992 | 2% | 5% | 0.053851648 | 0.005164641 | 0.000278124 | 0.004822402 | 90% |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.967011 | 70.59473241 | 25% | 20% | 0.320156212 | 0.000861205 | 0.00027572 | 0.004780712 | 91% |

| IPCC category/Group | Gas | 1990 emissions (kt $CO_2$ eq) | 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.519712 | 13.38625669 | 5% | 50% | 0.502493781 | 0.000501269 | 0.000251884 | 0.004367426 | 91% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.826737 | 0 | 2% | 10% | 0.10198039 | 0.002352141 | 0.000239872 | 0.004159147 | 92% |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.5960639 | 0.01036233 | 5% | 25% | 0.254950976 | 0.000865783 | 0.000220732 | 0.003827278 | 92% |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.2865 | 10.965 | 5% | 50% | 0.502493781 | 0.000412894 | 0.000207477 | 0.003597437 | 93% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.464312 | 0.705374886 | 2% | 5% | 0.053851648 | 0.003834409 | 0.000206489 | 0.003580318 | 93% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | 61.3521 | 0 | 2% | 20% | 0.200997512 | 0.001010377 | 0.000203083 | 0.003521261 | 93% |
| 3.B.5 Indirect $N_2O$ emissions from Manure Management | $N_2O$ | 137.520248 | 41.93797066 | 2% | 30% | 0.300665928 | 0.000667506 | 0.000200696 | 0.003479873 | 94% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 334.00881 | 238.7965288 | 2% | 5% | 0.053851648 | 0.00359416 | 0.000193551 | 0.00335599 | 94% |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 8.434081116 | 5% | 50% | 0.502493781 | 0.000315834 | 0.000158705 | 0.002751784 | 94% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.2522888 | 0 | 2% | 10% | 0.10198039 | 0.001535725 | 0.000156614 | 0.002715528 | 94% |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 40.7532233 | 5.647103039 | 25% | 20% | 0.320156212 | 0.000456069 | 0.000146013 | 0.002531727 | 95% |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.75045 | 613.35806 | 2% | 2% | 0.028284271 | 0.005027274 | 0.000142193 | 0.002465482 | 95% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.483828 | 73.41324777 | 2% | 5% | 0.053851648 | 0.002383064 | 0.000128332 | 0.002225149 | 95% |

| IPCC category/Group | Gas | 1990 emissions (kt $CO_2$ eq) | 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.8386568 | 0 | 2% | 10% | 0.10198039 | 0.001216011 | 0.000124009 | 0.002150198 | 95% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.415468 | 5.263181843 | 2% | 5% | 0.053851648 | 0.002260194 | 0.000121715 | 0.002110421 | 96% |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.5449979 | 1.136164465 | 2% | 11% | 0.110909091 | 0.001052624 | 0.000116746 | 0.002024252 | 96% |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 120.665767 | 42.94734024 | 25% | 20% | 0.320156212 | 0.000351495 | 0.000112533 | 0.001951216 | 96% |
| 2.D.3. Solvent Use | $CO_2$ | 41.0641984 | 32.19721064 | 2% | 20% | 0.200997512 | 0.000549994 | 0.000110548 | 0.001916784 | 96% |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.090525 | 13.021775 | 2% | 50% | 0.50039984 | 0.000198022 | 9.90904E-05 | 0.001718129 | 96% |
| 5.C.1 Waste Incineration | $N_2O$ | 4.84702453 | 4.3807102 | 43% | 100% | 1.08853112 | 8.70201E-05 | 9.47241E-05 | 0.001642422 | 97% |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.3784162 | 20.64571937 | 25% | 20% | 0.320156212 | 0.000290373 | 9.29647E-05 | 0.001611916 | 97% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.075709 | 320.5751539 | 2% | 11% | 0.108754816 | 0.000762546 | 8.29305E-05 | 0.001437933 | 97% |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.92 | 18.5 | 2% | 50% | 0.50039984 | 0.000162446 | 8.12882E-05 | 0.001409456 | 97% |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 8.94447 | 10.597476 | 10% | 30% | 0.316227766 | 0.000256313 | 8.10531E-05 | 0.001405381 | 97% |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.54125 | 13.1025 | 2% | 20% | 0.200997512 | 0.000366255 | 7.36163E-05 | 0.001276433 | 97% |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.2715045 | 0 | 2% | 10% | 0.10198039 | 0.000696148 | 7.09934E-05 | 0.001230956 | 97% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 0.18 | 2% | 50% | 0.50039984 | 0.000126688 | 6.33944E-05 | 0.001099196 | 97% |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.1551631 | 2.207274532 | 2% | 30% | 0.300665928 | 0.000198454 | 5.96682E-05 | 0.001034588 | 98% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.1626684 | 0.0057514 | 2% | 50% | 0.50039984 | 0.000117739 | 5.89167E-05 | 0.001021558 | 98% |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.911064 | 157.1324033 | 2% | 10% | 0.10198039 | 0.000551392 | 5.62312E-05 | 0.000974992 | 98% |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 6.219856 | 5.564080248 | 5% | 50% | 0.502493781 | 0.000109481 | 5.50137E-05 | 0.000953883 | 98% |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.1636853 | 2.934347457 | 2% | 50% | 0.50039984 | 0.000109062 | 5.45744E-05 | 0.000946266 | 98% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.6990443 | 45.0354735 | 2% | 5% | 0.053851648 | 0.000979091 | 5.27257E-05 | 0.000914211 | 98% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.66618252 | 0.181929 | 2% | 50% | 0.50039984 | 0.000102853 | 5.14676E-05 | 0.000892398 | 98% |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263264 | 5.4868 | 2% | 20% | 0.200997512 | 0.000240015 | 4.82424E-05 | 0.000836476 | 98% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.7792529 | 21.16428627 | 2% | 10% | 0.10198039 | 0.000397984 | 4.05866E-05 | 0.000703731 | 98% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.222067 | 93.81485986 | 2% | 5% | 0.053851648 | 0.000703849 | 3.79034E-05 | 0.000657208 | 98% |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.4845375 | 7.840283798 | 25% | 30% | 0.390512484 | 9.30028E-05 | 3.63187E-05 | 0.000629731 | 98% |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.2006075 | 24.62371876 | 2% | 50% | 0.50039984 | 7.00651E-05 | 3.50606E-05 | 0.000607916 | 98% |
| 2.D.1 Lubricant Use | $CO_2$ | 23.2510243 | 8.297813333 | 2% | 50% | 0.50039984 | 6.68796E-05 | 3.34665E-05 | 0.000580277 | 99% |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.37994 | 213.786 | 2% | 5% | 0.053851648 | 0.000608793 | 3.27845E-05 | 0.000568451 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.28631828 | 0.590724755 | 2% | 50% | 0.50039984 | 6.45594E-05 | 3.23055E-05 | 0.000560146 | 99% |

| IPCC category/Group | Gas | 1990 emissions (kt $CO_2$ eq) | 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008344 | 1.509107769 | 5% | 50% | 0.502493781 | 5.73383E-05 | 2.88121E-05 | 0.000499574 | 99% |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.72829 | 0.10175 | 2% | 50% | 0.50039984 | 5.75241E-05 | 2.8785E-05 | 0.000499104 | 99% |
| 3.H. Urea Application | $CO_2$ | 7.7088 | 4.726333333 | 20% | 50% | 0.538516481 | 5.30544E-05 | 2.85706E-05 | 0.000495387 | 99% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.1006644 | 1.5198 | 2% | 50% | 0.50039984 | 5.62252E-05 | 2.81351E-05 | 0.000487834 | 99% |
| 1.A.4.b Residential - Peat | $CH_4$ | 3.1875 | 0 | 2% | 50% | 0.50039984 | 5.24933E-05 | 2.62676E-05 | 0.000455455 | 99% |
| 2.A.3. Glass production | $CO_2$ | 0.35575206 | 0.942744575 | 2% | 86% | 0.860232527 | 3.00466E-05 | 2.5847E-05 | 0.000448162 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.15 | 2.625286653 | 5% | 50% | 0.502493781 | 5.07003E-05 | 2.54766E-05 | 0.000441739 | 99% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.8332289 | 12.58 | 2% | 5% | 0.053851648 | 0.000465399 | 2.50625E-05 | 0.000434559 | 99% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.0225 | 0 | 2% | 50% | 0.50039984 | 4.9776E-05 | 2.49079E-05 | 0.000431878 | 99% |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.00505 | 0.002425 | 2% | 50% | 0.50039984 | 4.93963E-05 | 2.47179E-05 | 0.000428584 | 99% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.5473935 | 0.397748377 | 2% | 10% | 0.10198039 | 0.000240894 | 2.45664E-05 | 0.000425957 | 99% |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.985987 | 11.52240459 | 25% | 30% | 0.390512484 | 6.02966E-05 | 2.35466E-05 | 0.000408275 | 99% |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.82447954 | 2.221483039 | 25% | 30% | 0.390512484 | 5.45608E-05 | 2.13067E-05 | 0.000369436 | 99% |
| 1.A.3.b Road Transportation - | $N_2O$ | 13.0741074 | 4.606850327 | 2% | 50% | 0.50039984 | 3.98548E-05 | 1.99433E-05 | 0.000345797 | 99% |

| IPCC category/Group | Gas | 1990 emissions (kt $CO_2$ eq) | 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| Gasoline | | | | | | | | | | |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.862588 | 0.237357 | 2% | 50% | 0.50039984 | 3.81026E-05 | 1.90665E-05 | 0.000330594 | 99% |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.00525 | 0.949410006 | 5% | 50% | 0.502493781 | 3.60727E-05 | 1.81263E-05 | 0.000314292 | 99% |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868375 | 1.276125 | 2% | 50% | 0.50039984 | 3.43015E-05 | 1.71645E-05 | 0.000297615 | 99% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 0.649625 | 2% | 50% | 0.50039984 | 3.28158E-05 | 1.6421E-05 | 0.000284724 | 99% |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344325 | 26.126175 | 10% | 0% | 0.1 | 0.000163426 | 1.63426E-05 | 0.000283364 | 99% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.6165255 | 0 | 2% | 5% | 0.053851648 | 0.000290118 | 1.56233E-05 | 0.000270893 | 99% |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.12456546 | 0.863788568 | 2% | 50% | 0.50039984 | 3.08468E-05 | 1.54357E-05 | 0.00026764 | 99% |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.26531 | 0.173975 | 2% | 50% | 0.50039984 | 3.06802E-05 | 1.53524E-05 | 0.000266195 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.87891384 | 0.0437464 | 2% | 50% | 0.50039984 | 2.92768E-05 | 1.46501E-05 | 0.000254018 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.424493 | 17.14603569 | 2% | 5% | 0.053851648 | 0.000267256 | 1.43922E-05 | 0.000249546 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.4629 | 4.554798669 | 10% | 5% | 0.111803399 | 0.000116445 | 1.30189E-05 | 0.000225735 | 100% |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.34142861 | 0.115643072 | 23% | 30% | 0.378021163 | 3.41554E-05 | 1.29115E-05 | 0.000223872 | 100% |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.149772 | 0.252487056 | 2% | 50% | 0.50039984 | 2.57873E-05 | 1.2904E-05 | 0.000223742 | 100% |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.41170685 | 0.369840648 | 2% | 50% | 0.50039984 | 2.56315E-05 | 1.2826E-05 | 0.00022239 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774375 | 0.127125 | 2% | 50% | 0.50039984 | 2.43796E-05 | 1.21996E-05 | 0.000211528 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.0786 | 0 | 2% | 20% | 0.200997512 | 5.06999E-05 | 1.01906E-05 | 0.000176694 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.07599 | 0.560538 | 2% | 50% | 0.50039984 | 2.00972E-05 | 1.00566E-05 | 0.000174372 | 100% |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.10804146 | 1.356526416 | 2% | 30% | 0.300665928 | 3.34168E-05 | 1.00473E-05 | 0.00017421 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692316 | 0 | 2% | 20% | 0.200997512 | 4.43384E-05 | 8.9119E-06 | 0.000154524 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.271776 | 0.556962 | 5% | 50% | 0.502493781 | 1.67367E-05 | 8.41007E-06 | 0.000145822 | 100% |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.997704 | 0 | 2% | 50% | 0.50039984 | 1.64307E-05 | 8.22191E-06 | 0.00014256 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030335 | 0.078225 | 2% | 50% | 0.50039984 | 1.39888E-05 | 6.99999E-06 | 0.000121373 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.05481907 | 3.13427 | 2% | 5% | 0.053851648 | 0.000118469 | 6.37974E-06 | 0.000110618 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.78871 | 0.02035 | 2% | 50% | 0.50039984 | 1.22138E-05 | 6.11179E-06 | 0.000105972 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.5005 | 0.5315 | 2% | 50% | 0.50039984 | 1.20002E-05 | 6.00489E-06 | 0.000104119 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.7015 | 0 | 2% | 50% | 0.50039984 | 1.15526E-05 | 5.78094E-06 | 0.000100236 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.3505 | 5% | 50% | 0.502493781 | 1.0533E-05 | 5.29277E-06 | 9.17713E-05 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.65129688 | 0.0069732 | 2% | 50% | 0.50039984 | 1.04603E-05 | 5.23433E-06 | 9.07581E-05 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.62775 | 0 | 2% | 50% | 0.50039984 | 1.03381E-05 | 5.17318E-06 | 8.96978E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.615519 | 0 | 2% | 50% | 0.50039984 | 1.01367E-05 | 5.07239E-06 | 8.79502E-05 | 100% |
| 5.C.1 Waste Incineration | $CO_2$ | 0.81070759 | 0.56263867 | 43% | 40% | 0.587281874 | 8.07747E-06 | 4.74375E-06 | 8.2252E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.4367772 | 0.865392 | 2% | 50% | 0.50039984 | 9.29768E-06 | 4.65256E-06 | 8.06708E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.64092648 | 0.04917 | 2% | 50% | 0.50039984 | 8.68241E-06 | 4.34468E-06 | 7.53324E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.76125 | 0.550125 | 2% | 50% | 0.50039984 | 8.41537E-06 | 4.21105E-06 | 7.30154E-05 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.20535 | 0.726 | 2% | 50% | 0.50039984 | 7.80007E-06 | 3.90315E-06 | 6.76768E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.4832964 | 0.010728 | 2% | 50% | 0.50039984 | 7.55058E-06 | 3.77831E-06 | 6.55121E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.45424 | 0.431444174 | 5% | 50% | 0.502493781 | 7.5172E-06 | 3.77735E-06 | 6.54954E-05 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.47777148 | 0.010728 | 2% | 50% | 0.50039984 | 7.45959E-06 | 3.73278E-06 | 6.47227E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423011 | 0.0303066 | 2% | 50% | 0.50039984 | 5.8121E-06 | 2.90837E-06 | 5.04283E-05 | 100% |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.4500694 | 0.344594088 | 2% | 50% | 0.50039984 | 5.71221E-06 | 2.85839E-06 | 4.95617E-05 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.3177723 | 0 | 2% | 50% | 0.50039984 | 5.23323E-06 | 2.61871E-06 | 4.54058E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.2955862 | 0.004619 | 2% | 50% | 0.50039984 | 4.69194E-06 | 2.34785E-06 | 4.07093E-05 | 100% |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.27267 | 0 | 2% | 50% | 0.50039984 | 4.49046E-06 | 2.24703E-06 | 3.89612E-05 | 100% |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273195 | 0.004725 | 2% | 50% | 0.50039984 | 4.31915E-06 | 2.1613E-06 | 3.74749E-05 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.17277176 | 0.3465 | 20% | 5% | 0.206155281 | 1.03515E-05 | 2.13401E-06 | 3.70016E-05 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CH_4$ | 0.2325 | 0 | 2% | 50% | 0.50039984 | 3.82892E-06 | 1.91599E-06 | 3.32214E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.268845 | 0.020625 | 2% | 50% | 0.50039984 | 3.64195E-06 | 1.82243E-06 | 3.15991E-05 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.2179572 | 0 | 2% | 50% | 0.50039984 | 3.58943E-06 | 1.79615E-06 | 3.11434E-05 | 100% |
| 2.G.3. $N_2O$ from product uses | $N_2O$ | 1.30226 | 2.01448 | 2% | 2% | 0.028284271 | 5.5277E-05 | 1.56347E-06 | 2.7109E-05 | 100% |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.1860712 | 0 | 2% | 50% | 0.50039984 | 3.06431E-06 | 1.53338E-06 | 2.65873E-05 | 100% |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.78185 | 0.439375 | 25% | 30% | 0.390512484 | 3.8581E-06 | 1.50664E-06 | 2.61236E-05 | 100% |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.1193192 | 0.1267096 | 2% | 50% | 0.50039984 | 2.86084E-06 | 1.43156E-06 | 2.48219E-05 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.28480456 | 0.0500044 | 2% | 50% | 0.50039984 | 2.78584E-06 | 1.39403E-06 | 2.41712E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.168 | 0.00275 | 2% | 50% | 0.50039984 | 2.66197E-06 | 1.33205E-06 | 2.30964E-05 | 100% |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.0014633 | 0.054450618 | 20% | 60% | 0.632455532 | 2.0497E-06 | 1.29635E-06 | 2.24773E-05 | 100% |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.23893 | 0.04195 | 2% | 50% | 0.50039984 | 2.33711E-06 | 1.16949E-06 | 2.02778E-05 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.00297234 | 0.049156808 | 20% | 60% | 0.632455532 | 1.82323E-06 | 1.15311E-06 | 1.99938E-05 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127395 | 0.0003874 | 2% | 50% | 0.50039984 | 2.08325E-06 | 1.04246E-06 | 1.80752E-05 | 100% |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181482 | 0.1311498 | 2% | 50% | 0.50039984 | 2.00622E-06 | 1.00391E-06 | 1.74069E-05 | 100% |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.106875 | 0.000325 | 2% | 50% | 0.50039984 | 1.74769E-06 | 8.74545E-07 | 1.51637E-05 | 100% |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091425 | 0 | 2% | 50% | 0.50039984 | 1.50563E-06 | 7.53418E-07 | 1.30635E-05 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.1708732 | 0.0403194 | 2% | 50% | 0.50039984 | 1.27842E-06 | 6.39723E-07 | 1.10922E-05 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.08118414 | 0.0028906 | 2% | 50% | 0.50039984 | 1.22689E-06 | 6.13935E-07 | 1.0645E-05 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.01100503 | 0.28 | 2% | 5% | 0.053851648 | 1.04828E-05 | 5.64517E-07 | 9.78816E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.00425 | 0.03135 | 2% | 50% | 0.50039984 | 1.124E-06 | 5.6245E-07 | 9.75233E-06 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.00045315 | 0.029353 | 2% | 50% | 0.50039984 | 1.11047E-06 | 5.5568E-07 | 9.63495E-06 | 100% |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.14335 | 0.033825 | 2% | 50% | 0.50039984 | 1.0725E-06 | 5.3668E-07 | 9.3055E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.05379496 | 0.0511368 | 2% | 50% | 0.50039984 | 1.06167E-06 | 5.31259E-07 | 9.21151E-06 | 100% |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.12419448 | 0.025926 | 2% | 50% | 0.50039984 | 1.05788E-06 | 5.29363E-07 | 9.17863E-06 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.0681075 | 0.002425 | 2% | 50% | 0.50039984 | 1.02927E-06 | 5.15046E-07 | 8.93039E-06 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.02384 | 0.032918912 | 10% | 50% | 0.509901951 | 8.61138E-07 | 4.39096E-07 | 7.61348E-06 | 100% |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.74500904 | 0.299750179 | 2% | 50% | 0.50039984 | 8.52919E-07 | 4.26801E-07 | 7.4003E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050064 | 0 | 2% | 50% | 0.50039984 | 8.24479E-07 | 4.12569E-07 | 7.15354E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.057625 | 0.004375 | 2% | 50% | 0.50039984 | 7.82371E-07 | 3.91498E-07 | 6.78819E-06 | 100% |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001126 | 0.017 | 2% | 50% | 0.50039984 | 6.28917E-07 | 3.1471E-07 | 5.45676E-06 | 100% |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.06875 | 1.15638E-05 | 10% | 25% | 0.26925824 | 1.13177E-06 | 3.04738E-07 | 5.28385E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.0362964 | 0.0004768 | 2% | 50% | 0.50039984 | 5.79588E-07 | 2.90026E-07 | 5.02876E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034425 | 0 | 2% | 50% | 0.50039984 | 5.66928E-07 | 2.83691E-07 | 4.91891E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.024287 | 0.024734 | 2% | 50% | 0.50039984 | 5.42046E-07 | 2.7124E-07 | 4.70303E-06 | 100% |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CH_4$ | 0.0315 | 0 | 2% | 50% | 0.50039984 | 5.18757E-07 | 2.59586E-07 | 4.50097E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020375 | 0.02075 | 2% | 50% | 0.50039984 | 4.54737E-07 | 2.2755E-07 | 3.9455E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - | $CH_4$ | 0.02314 | 0.02145 | 2% | 50% | 0.50039984 | 4.35862E-07 | 2.18105E-07 | 3.78173E-06 | 100% |

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|---|---|---|---|---|---|---|---|---|---|---|
| Liquid Fuels | | | | | | | | | | |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.026721 | 0.0006 | 2% | 50% | 0.50039984 | 4.17203E-07 | 2.08768E-07 | 3.61984E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.09466268 | 0.0515242 | 2% | 50% | 0.50039984 | 4.03394E-07 | 2.01858E-07 | 3.50002E-06 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079415 | 0.043225 | 2% | 50% | 0.50039984 | 3.38418E-07 | 1.69344E-07 | 2.93626E-06 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.0177725 | 0 | 2% | 50% | 0.50039984 | 2.92686E-07 | 1.4646E-07 | 2.53947E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015225 | 0.00025 | 2% | 50% | 0.50039984 | 2.41211E-07 | 1.20702E-07 | 2.09285E-06 | 100% |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.013857 | 0 | 2% | 50% | 0.50039984 | 2.28204E-07 | 1.14193E-07 | 1.98E-06 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.01272162 | 0 | 2% | 50% | 0.50039984 | 2.09506E-07 | 1.04837E-07 | 1.81776E-06 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.00295205 | 0.005924494 | 20% | 50% | 0.538516481 | 1.77024E-07 | 9.53303E-08 | 1.65293E-06 | 100% |
| 1.B.2.b Natural Gas | $CO_2$ | 0.008686 | 0.011105 | 32% | 0% | 0.322375 | 2.79899E-07 | 9.02323E-08 | 1.56454E-06 | 100% |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.02475 | 0.014988474 | 10% | 50% | 0.509901951 | 1.63254E-07 | 8.32437E-08 | 1.44336E-06 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.01272758 | 0.0094168 | 2% | 50% | 0.50039984 | 1.49043E-07 | 7.45812E-08 | 1.29316E-06 | 100% |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.0106775 | 0.0079 | 2% | 50% | 0.50039984 | 1.25036E-07 | 6.25681E-08 | 1.08487E-06 | 100% |

| IPCC category/Group | Gas | 1990 emissions (kt $CO_2$ eq) | 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 9.37E-05 | 0.002384 | 2% | 50% | 0.50039984 | 8.92537E-08 | 4.46625E-08 | 7.74404E-07 | 100% |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 9.504E-06 | 0.0021375 | 2% | 50% | 0.50039984 | 8.12521E-08 | 4.06585E-08 | 7.04979E-07 | 100% |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.006946 | 0.00145 | 2% | 50% | 0.50039984 | 5.91656E-08 | 2.96064E-08 | 5.13346E-07 | 100% |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.00021951 | 0.000440227 | 20% | 50% | 0.538516481 | 1.31515E-08 | 7.08231E-09 | 1.228E-07 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.0007115 | 0 | 2% | 50% | 0.50039984 | 1.17173E-08 | 5.86335E-09 | 1.01665E-07 | 100% |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.002806 | 0.002657 | 10% | 0% | 0.1 | 5.49837E-08 | 5.49837E-09 | 9.53362E-08 | 100% |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 1.9652E-06 | 0.00005 | 2% | 50% | 0.50039984 | 1.87193E-09 | 9.36714E-10 | 1.62417E-08 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0 | 0.2955 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0 | 0.469648 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 0 | 3.906691677 | 2% | 5% | 0.053851648 | | 0 | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0 | 0.0018 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0 | 0.0021456 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 0 | 1.12172959 | 2% | 11% | 0.110909091 | | 0 | 0 | 100% |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0 | 0.211451058 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0 | 0.000521299 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |

| IPCC category/Group | Gas | 1990 emissions (kt $CO_2$ eq) | 2014 emissions (kt $CO_2$ eq) | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined Uncertainty | Trend assessment | Trend assessment with Uncertainty | % Contribution to Trend | Cumulative total of contribution to trend |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0 | 0.334983061 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0 | 0.004850822 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $CH_4$ | 0 | 0.00225 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0 | 0.003576 | 5% | 50% | 0.502493781 | | 0 | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 0 | 2.1257 | 2% | 20% | 0.200997512 | | 0 | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0 | 0.02175 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0 | 0.034568 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | 0 | 107.5693 | 2% | 2% | 0.028284271 | | 0 | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CH_4$ | 0 | 0.937280723 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 0 | 1.489651495 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.g Other - Peat | $CO_2$ | 0 | 1.331164465 | 2% | 10% | 0.10198039 | | 0 | 0 | 100% |
| 1.A.2.g Other - Peat | $CH_4$ | 0 | 0.000575 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.2.g Other - Peat | $N_2O$ | 0 | 0.005811 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.3.b Road Transportation - | $CH_4$ | 0 | 0.023009615 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |

| **IPCC category/Group** | **Gas** | **1990 emissions (kt $CO_2$ eq)** | **2014 emissions (kt $CO_2$ eq)** | **Activity data uncertainty** | **Emission factor / estimation parameter uncertainty** | **Combined Uncertainty** | **Trend assessment** | **Trend assessment with Uncertainty** | **% Contribution to Trend** | **Cumulative total of contribution to trend** |
|---|---|---|---|---|---|---|---|---|---|---|
| Biomass | | | | | | | | | | |
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0 | 0.349076786 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0 | 0.0022825 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0 | 0.0346276 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 0 | 9.442494289 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0 | 0.018743571 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0 | 0.076423393 | 2% | 50% | 0.50039984 | | 0 | 0 | 100% |
| 2.D.2 Paraffin wax use | $CO_2$ | 0 | 4.911573333 | 2% | 100% | 1.00019998 | | 0 | 0 | 100% |
| 2.D.3.d Urea Use | $CO_2$ | 0 | 0.817 | 20% | 10% | 0.223606798 | | 0 | 0 | 100% |
| 2.F.1. Refrigeration and air conditioning | HFCs | 0 | 206.3769351 | 50% | 50% | 0.707106781 | | 0 | 0 | 100% |
| 2.F.2 Foam blowing agents | HFCs | 0 | 0.961490119 | 50% | 50% | 0.707106781 | | 0 | 0 | 100% |
| 2.F.3. Fire Protection | HFCs | 0 | 0.02767976 | 50% | 50% | 0.707106781 | | 0 | 0 | 100% |
| 2.F.4. Aerosols | HFCs | 0 | 4.697766137 | 50% | 50% | 0.707106781 | | 0 | 0 | 100% |
| 2.G.1. Electrical equipment | SF6 | 0 | 8.577903643 | 2% | 30% | 0.300665928 | | 0 | 0 | 100% |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 0 | 301.0244136 | 7% | 52% | 0.524690385 | | 0 | 0 | 100% |
| TOTAL | | 26256.43 | 11353.38 | | | 113.7834066 | 0.33861408 | 0.057673426 | 1 | |

# *Annex 2: Assessment of Uncertainty*

## A.2.1 Approach 1 uncertainty analysis for 2014 including LULUCF

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.621305 | 2.456340066 | 2% | 10% | 0.1020 | 0.0000 | 0.1489 | 0.0001 | 0.0149 | 0.0000 | 0.000221695 |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 16.555 | 2% | 20% | 0.2010 | 0.0000 | 0.0097 | 0.0009 | 0.0019 | 0.0000 | 3.79914E-06 |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.318679 | 1575.698976 | 2% | 5% | 0.0539 | 0.0000 | 0.0410 | 0.0884 | 0.0021 | 0.0025 | 1.04543E-05 |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.826737 | 0 | 2% | 10% | 0.1020 | 0.0000 | 0.0070 | 0.0000 | 0.0007 | 0.0000 | 4.88764E-07 |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.0786 | 0 | 2% | 20% | 0.2010 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 9.0848E-10 |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.00505 | 0.002425 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 5.39994E-09 |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.057625 | 0.004375 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.65845E-12 |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.20535 | 0.726 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.50264E-11 |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 8.434081116 | 5% | 50% | 0.5025 | 0.0000 | 0.0005 | 0.0005 | 0.0002 | 0.0000 | 5.33069E-08 |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034425 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.09967E-13 |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CH_4$ | 0.0315 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.94444E-13 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.1626684 | 0.0057514 | 2% | 50% | 0.5004 | 0.0000 | 0.0004 | 0.0000 | 0.0002 | 0.0000 | 3.06787E-08 |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030335 | 0.078225 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.30197E-10 |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.4367772 | 0.865392 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.20811E-10 |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.519712 | 13.38625669 | 5% | 50% | 0.5025 | 0.0000 | 0.0007 | 0.0008 | 0.0004 | 0.0001 | 1.34272E-07 |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.615519 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.26972E-10 |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050064 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.50155E-12 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.7792529 | 21.16428627 | 2% | 10% | 0.1020 | 0.0000 | 0.0000 | 0.0012 | 0.0000 | 0.0000 | 1.13352E-09 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.69904433 | 45.0354735 | 2% | 5% | 0.0539 | 0.0000 | 0.0003 | 0.0025 | 0.0000 | 0.0001 | 5.38515E-09 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.83865681 | 0 | 2% | 10% | 0.1020 | 0.0000 | 0.0036 | 0.0000 | 0.0004 | 0.0000 | 1.30642E-07 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CH_4$ | 0.02314 | 0.02145 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.38061E-15 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020375 | 0.02075 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.97676E-15 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0 | 0.2955 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.00046E-11 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.0177725 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.89229E-13 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.05379496 | 0.0511368 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.02513E-14 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.024287 | 0.024734 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.13339E-14 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0 | 0.469648 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.7683E-10 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.3177723 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.04954E-11 |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.25228881 | 0 | 2% | 10% | 0.1020 | 0.0000 | 0.0046 | 0.0000 | 0.0005 | 0.0000 | 2.08364E-07 |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.4643123 | 0.705374886 | 2% | 5% | 0.0539 | 0.0000 | 0.0114 | 0.0000 | 0.0006 | 0.0000 | 3.26989E-07 |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CO_2$ | 61.3521 | 0 | 2% | 20% | 0.2010 | 0.0000 | 0.0030 | 0.0000 | 0.0006 | 0.0000 | 3.60777E-07 |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091425 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.00749E-12 |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.106875 | 0.000325 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.79535E-12 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.62775 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.36082E-10 |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.2179572 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.84598E-11 |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127395 | 0.0003874 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.65526E-12 |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.997704 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.96339E-10 |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 0 | 3.906691677 | 2% | 5% | 0.0539 | 0.0000 | 0.0002 | 0.0002 | 0.0000 | 0.0000 | 1.58345E-10 |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0 | 0.0018 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.55472E-15 |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0 | 0.0021456 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.62991E-15 |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.6786727 | 10.10088453 | 2% | 10% | 0.1020 | 0.0000 | 0.0130 | 0.0006 | 0.0013 | 0.0000 | 1.68396E-06 |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.42449305 | 17.14603569 | 2% | 5% | 0.0539 | 0.0000 | 0.0002 | 0.0010 | 0.0000 | 0.0000 | 8.25252E-10 |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 0 | 1.12172959 | 2% | 11% | 0.1109 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 5.02435E-11 |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273195 | 0.004725 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.29592E-11 |
| 1.A.2.c Chemicals - Gaseous Fuels | $CH_4$ | 0.0106775 | 0.0079 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.74629E-15 |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0 | 0.211451058 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.58452E-11 |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0 | 0.000521299 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.14275E-16 |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.65129688 | 0.0069732 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.47931E-10 |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.01272758 | 0.0094168 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.48123E-15 |
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0 | 0.334983061 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.99616E-11 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0 | 0.004850822 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.85536E-14 |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.54739345 | 0.397748377 | 2% | 10% | 0.1020 | 0.0000 | 0.0007 | 0.0000 | 0.0001 | 0.0000 | 5.45829E-09 |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692316 | 0 | 2% | 20% | 0.2010 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 6.94802E-10 |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.4154681 | 5.263181843 | 2% | 5% | 0.0539 | 0.0000 | 0.0070 | 0.0003 | 0.0004 | 0.0000 | 1.2322E-07 |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015225 | 0.00025 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.33694E-13 |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.0007115 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.03277E-16 |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.0681075 | 0.002425 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.55692E-12 |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $CH_4$ | 0 | 0.00225 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.0586E-15 |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.0362964 | 0.0004768 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.65683E-13 |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.01272162 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.69561E-14 |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.08118414 | 0.0028906 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.63303E-12 |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0 | 0.003576 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.02519E-14 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.2058686 | 26.17773966 | 2% | 11% | 0.1111 | 0.0000 | 0.0376 | 0.0015 | 0.0041 | 0.0000 | 1.68692E-05 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid | $CO_2$ | 103.071464 | 2.2704 | 2% | 20% | 0.2010 | 0.0000 | 0.0049 | 0.0001 | 0.0010 | 0.0000 | 9.6749E-07 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuels | | | | | | | | | | | | |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.2220665 | 93.81485986 | 2% | 5% | 0.0539 | 0.0000 | 0.0033 | 0.0053 | 0.0002 | 0.0001 | 4.88363E-08 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 0 | 2.1257 | 2% | 20% | 0.2010 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 5.79609E-10 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.78871 | 0.02035 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.50969E-10 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.026721 | 0.0006 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.06036E-13 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079415 | 0.043225 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.40458E-13 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.3505 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.37514E-11 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0 | 0.02175 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.73007E-13 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.87891384 | 0.0437464 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 2.00367E-09 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid | $N_2O$ | 0.47777148 | 0.010728 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.29807E-10 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuels | | | | | | | | | | | | |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.09466268 | 0.0515242 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.67917E-13 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.271776 | 0.556962 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.52036E-11 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0 | 0.034568 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.42209E-13 |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.5769252 | 20.35027526 | 2% | 10% | 0.1020 | 0.0000 | 0.0122 | 0.0011 | 0.0012 | 0.0000 | 1.50151E-06 |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.4292 | 118.6284 | 2% | 20% | 0.2010 | 0.0000 | 0.0058 | 0.0067 | 0.0012 | 0.0002 | 1.40302E-06 |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.4838285 | 73.41324777 | 2% | 5% | 0.0539 | 0.0000 | 0.0113 | 0.0041 | 0.0006 | 0.0001 | 3.31452E-07 |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CO_2$ | 0 | 107.5693 | 2% | 2% | 0.0283 | 0.0000 | 0.0060 | 0.0060 | 0.0001 | 0.0002 | 4.36545E-08 |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.268845 | 0.020625 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.60262E-11 |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.00425 | 0.03135 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.02916E-13 |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.14335 | 0.033825 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.55841E-12 |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.00525 | 0.949410006 | 5% | 50% | 0.5025 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 7.15811E-10 |
| 1.A.2.f Non-metallic Minerals - | $CH_4$ | 0 | 0.937280723 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 6.92689E-10 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Other Fossil Fuels | | | | | | | | | | | | |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.64092648 | 0.04917 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.04753E-10 |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.07599 | 0.560538 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.92749E-10 |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.1708732 | 0.0403194 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.31861E-12 |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008344 | 1.509107769 | 5% | 50% | 0.5025 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 1.80855E-09 |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 0 | 1.489651495 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 1.74972E-09 |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.7039841 | 104.8142275 | 2% | 10% | 0.1020 | 0.0000 | 0.0331 | 0.0059 | 0.0033 | 0.0002 | 1.09572E-05 |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263264 | 5.4868 | 2% | 20% | 0.2010 | 0.0000 | 0.0010 | 0.0003 | 0.0002 | 0.0000 | 4.22601E-08 |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.168965 | 91.04761992 | 2% | 5% | 0.0539 | 0.0000 | 0.0205 | 0.0051 | 0.0010 | 0.0001 | 1.07643E-06 |
| 1.A.2.g Other - Peat | $CO_2$ | 0 | 1.331164465 | 2% | 10% | 0.1020 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 6.0167E-11 |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.26531 | 0.173975 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 2.55728E-09 |
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.006946 | 0.00145 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.67395E-14 |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.23893 | 0.04195 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.18323E-11 |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.2865 | 10.965 | 5% | 50% | 0.5025 | 0.0000 | 0.0006 | 0.0006 | 0.0003 | 0.0000 | 9.2127E-08 |
| 1.A.2.g Other - Peat | $CH_4$ | 0 | 0.000575 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.60696E-16 |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.149772 | 0.252487056 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 2.07403E-09 |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.12419448 | 0.025926 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.35153E-12 |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.28480456 | 0.0500044 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.10207E-11 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455344 | 17.42704 | 5% | 50% | 0.5025 | 0.0000 | 0.0010 | 0.0010 | 0.0005 | 0.0001 | 2.32711E-07 |
| 1.A.2.g Other - Peat | $N_2O$ | 0 | 0.005811 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.66257E-14 |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.011005031 | 0.28 | 2% | 5% | 0.0539 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.71831E-13 |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.054819072 | 3.13427 | 2% | 5% | 0.0539 | 0.0000 | 0.0002 | 0.0002 | 0.0000 | 0.0000 | 9.95796E-11 |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 1.96519E-06 | 0.00005 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.8387E-18 |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.000009504 | 0.0021375 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.57473E-15 |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 9.36998E-05 | 0.002384 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.18007E-15 |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.000453151 | 0.029353 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.61234E-13 |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.750448 | 613.35806 | 2% | 2% | 0.0283 | 0.0000 | 0.0499 | 0.0344 | 0.0010 | 0.0010 | 1.94391E-06 |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.1359677 | 1880.266 | 2% | 2% | 0.0283 | 0.0000 | 0.0752 | 0.1054 | 0.0015 | 0.0030 | 1.11564E-05 |
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.95737306 | 165.2425801 | 2% | 5% | 0.0539 | 0.0000 | 0.0075 | 0.0093 | 0.0004 | 0.0003 | 2.07654E-07 |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.4629 | 4.554798669 | 10% | 5% | 0.1118 | 0.0000 | 0.0001 | 0.0003 | 0.0000 | 0.0000 | 1.32292E-09 |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.6165255 | 0 | 2% | 5% | 0.0539 | 0.0000 | 0.0009 | 0.0000 | 0.0000 | 0.0000 | 1.85918E-09 |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.15516309 | 2.207274532 | 2% | 30% | 0.3007 | 0.0000 | 0.0007 | 0.0001 | 0.0002 | 0.0000 | 4.61537E-08 |
| 1.A.3.b Road Transportation - | $CH_4$ | 1.108041461 | 1.356526416 | 2% | 30% | 0.3007 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 4.74779E-11 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diesel Oil | | | | | | | | | | | | |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.124565463 | 0.863788568 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.49948E-10 |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.02475 | 0.014988474 | 10% | 50% | 0.5099 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.85661E-14 |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.7015 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.94812E-10 |
| 1.A.3.b Road Transportation - Biomass | $CH_4$ | 0 | 0.023009615 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.17462E-13 |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 13.07410741 | 4.606850327 | 2% | 50% | 0.5004 | 0.0000 | 0.0004 | 0.0003 | 0.0002 | 0.0000 | 3.64768E-08 |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.593827044 | 19.44722022 | 2% | 50% | 0.5004 | 0.0000 | 0.0008 | 0.0011 | 0.0004 | 0.0000 | 1.67653E-07 |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.163685304 | 2.934347457 | 2% | 50% | 0.5004 | 0.0000 | 0.0002 | 0.0002 | 0.0001 | 0.0000 | 6.14612E-09 |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.02384 | 0.032918912 | 10% | 50% | 0.5099 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.83316E-13 |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.27267 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.45415E-11 |
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0 | 0.349076786 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.60817E-11 |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.37994 | 213.786 | 2% | 5% | 0.0539 | 0.0000 | 0.0140 | 0.0120 | 0.0007 | 0.0003 | 6.0643E-07 |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.745009038 | 0.299750179 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.68832E-11 |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0 | 0.0022825 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.1079E-15 |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.20060747 | 24.62371876 | 2% | 50% | 0.5004 | 0.0000 | 0.0016 | 0.0014 | 0.0008 | 0.0000 | 6.53743E-07 |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0 | 0.0346276 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.45461E-13 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.172771761 | 0.3465 | 20% | 5% | 0.2062 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.04982E-11 |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.8332289 | 12.58 | 2% | 5% | 0.0539 | 0.0000 | 0.0007 | 0.0007 | 0.0000 | 0.0000 | 1.5022E-09 |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.00295205 | 0.005924494 | 20% | 50% | 0.5385 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.7634E-14 |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001126 | 0.017 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.02364E-13 |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000219506 | 0.000440227 | 20% | 50% | 0.5385 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.73135E-17 |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.1006644 | 1.5198 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 1.61737E-09 |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.294341 | 155.5621374 | 2% | 10% | 0.1020 | 0.0000 | 0.0406 | 0.0087 | 0.0041 | 0.0002 | 1.65154E-05 |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.784936 | 38.5022 | 2% | 20% | 0.2010 | 0.0000 | 0.0668 | 0.0022 | 0.0134 | 0.0001 | 0.000178759 |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CO_2$ | 334.0088098 | 238.7965288 | 2% | 5% | 0.0539 | 0.0000 | 0.0030 | 0.0134 | 0.0001 | 0.0004 | 1.65334E-07 |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.54499789 | 1.136164465 | 2% | 11% | 0.1109 | 0.0000 | 0.0032 | 0.0001 | 0.0003 | 0.0000 | 1.2139E-07 |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 0.649625 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 4.53465E-09 |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.72829 | 0.10175 | 2% | 50% | 0.5004 | 0.0000 | 0.0002 | 0.0000 | 0.0001 | 0.0000 | 7.81491E-09 |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.76125 | 0.550125 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.10628E-11 |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 34.97326278 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0020 | 0.0000 | 0.0001 | 1.97382E-08 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.168 | 0.00275 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.62806E-11 |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.411706848 | 0.369840648 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 2.36823E-09 |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.66618252 | 0.181929 | 2% | 50% | 0.5004 | 0.0000 | 0.0003 | 0.0000 | 0.0002 | 0.0000 | 2.49837E-08 |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181482 | 0.1311498 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.28752E-13 |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $N_2O$ | 6.219856 | 5.564080248 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0003 | 0.0000 | 0.0000 | 5.0074E-10 |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.2955862 | 0.004619 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.0486E-11 |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.9110639 | 157.1324033 | 2% | 10% | 0.1020 | 0.0000 | 0.0073 | 0.0088 | 0.0007 | 0.0002 | 6.00578E-07 |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.8184 | 50.2326 | 2% | 20% | 0.2010 | 0.0000 | 0.0268 | 0.0028 | 0.0054 | 0.0001 | 2.88017E-05 |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.6011945 | 230.7118474 | 2% | 5% | 0.0539 | 0.0000 | 0.0022 | 0.0129 | 0.0001 | 0.0004 | 1.4582E-07 |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.27150449 | 0 | 2% | 10% | 0.1020 | 0.0000 | 0.0021 | 0.0000 | 0.0002 | 0.0000 | 4.28179E-08 |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868375 | 1.276125 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 2.14984E-10 |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.03 | 3.9825 | 2% | 50% | 0.5004 | 0.0000 | 0.0021 | 0.0002 | 0.0011 | 0.0000 | 1.13196E-06 |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.5005 | 0.5315 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.73515E-12 |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.42474185 | 101.6540154 | 10% | 10% | 0.1414 | 0.0000 | 0.0010 | 0.0057 | 0.0001 | 0.0008 | 6.5935E-07 |
| 1.A.4.b Residential - Peat | $CH_4$ | 3.1875 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0002 | 0.0000 | 0.0001 | 0.0000 | 6.0868E-09 |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.4500694 | 0.344594088 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.13525E-12 |

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| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.862588 | 0.237357 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 4.02109E-09 |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.1193192 | 0.1267096 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.39624E-13 |
| 1.A.4.b Residential - Biomass Fuels | $N_2O$ | 8.94447 | 10.597476 | 10% | 30% | 0.3162 | 0.0000 | 0.0002 | 0.0006 | 0.0000 | 0.0001 | 9.26179E-09 |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.1860712 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.07419E-11 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.0757089 | 320.5751539 | 2% | 11% | 0.1088 | 0.0000 | 0.0160 | 0.0180 | 0.0017 | 0.0005 | 3.20028E-06 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.28152 | 2.2704 | 2% | 50% | 0.5004 | 0.0000 | 0.0049 | 0.0001 | 0.0024 | 0.0000 | 5.95204E-06 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.5312078 | 55.18201994 | 2% | 50% | 0.5004 | 0.0000 | 0.0350 | 0.0031 | 0.0175 | 0.0001 | 0.000306287 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.0225 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 5.47295E-09 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.286318275 | 0.590724755 | 2% | 50% | 0.5004 | 0.0000 | 0.0002 | 0.0000 | 0.0001 | 0.0000 | 1.2731E-08 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 0.18 | 2% | 50% | 0.5004 | 0.0000 | 0.0004 | 0.0000 | 0.0002 | 0.0000 | 3.74155E-08 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774375 | 0.127125 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 1.58934E-09 |

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| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.15 | 2.625286653 | 5% | 50% | 0.5025 | 0.0000 | 0.0003 | 0.0001 | 0.0002 | 0.0000 | 2.27153E-08 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CH_4$ | 0.2325 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.23844E-11 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.26924002 | 33.54418198 | 2% | 50% | 0.5004 | 0.0000 | 0.0002 | 0.0019 | 0.0001 | 0.0001 | 1.69065E-08 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.4832964 | 0.010728 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.32907E-10 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423011 | 0.0303066 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.03297E-11 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.45424 | 0.431444174 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.55113E-10 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.013857 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.15035E-13 |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 0 | 9.442494289 | 2% | 50% | 0.5004 | 0.0000 | 0.0005 | 0.0005 | 0.0003 | 0.0000 | 7.03027E-08 |
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0 | 0.018743571 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.77015E-13 |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0 | 0.076423393 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.60523E-12 |
| 1.B.2.b Natural Gas | $CO_2$ | 0.008686 | 0.011105 | 32% | 0% | 0.3224 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.05863E-14 |
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 109.190125 | 32% | 0% | 0.3224 | 0.0000 | 0.0026 | 0.0061 | 0.0000 | 0.0028 | 7.79095E-06 |

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| 1.B.2.c Venting and Flaring | $CO_2$ | 0.002806 | 0.002657 | 10% | 0% | 0.1000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.43899E-16 |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344325 | 26.126175 | 10% | 0% | 0.1000 | 0.0000 | 0.0020 | 0.0015 | 0.0000 | 0.0002 | 4.29193E-08 |
| 2.A.1. Cement Production | $CO_2$ | 370.8039966 | 555.775815 | 10% | 5% | 0.1118 | 0.0000 | 0.0130 | 0.0312 | 0.0007 | 0.0044 | 1.98453E-05 |
| 2.A.2. Lime Production | $CO_2$ | 148.8573814 | 0.459881348 | 2% | 50% | 0.5004 | 0.0000 | 0.0073 | 0.0000 | 0.0036 | 0.0000 | 1.31789E-05 |
| 2.A.3. Glass production | $CO_2$ | 0.355752064 | 0.942744575 | 2% | 86% | 0.8602 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 9.31448E-10 |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.184752 | 10.8326905 | 2% | 50% | 0.5004 | 0.0000 | 0.0028 | 0.0006 | 0.0014 | 0.0000 | 1.93137E-06 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.59606386 | 0.01036233 | 5% | 25% | 0.2550 | 0.0000 | 0.0026 | 0.0000 | 0.0006 | 0.0000 | 4.14109E-07 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.06875 | 1.15638E-05 | 10% | 25% | 0.2693 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.07633E-13 |
| 2.D.1 Lubricant Use | $CO_2$ | 23.25102433 | 8.297813333 | 2% | 50% | 0.5004 | 0.0000 | 0.0007 | 0.0005 | 0.0003 | 0.0000 | 1.1338E-07 |
| 2.D.2 Paraffin wax use | $CO_2$ | 0 | 4.911573333 | 2% | 100% | 1.0002 | 0.0000 | 0.0003 | 0.0003 | 0.0003 | 0.0000 | 7.59031E-08 |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.001463305 | 0.054450618 | 20% | 60% | 0.6325 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.94576E-12 |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.002972338 | 0.049156808 | 20% | 60% | 0.6325 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.06152E-12 |
| 2.D.3. Solvent Use | $CO_2$ | 41.0641984 | 32.19721064 | 2% | 20% | 0.2010 | 0.0000 | 0.0002 | 0.0018 | 0.0000 | 0.0001 | 4.28626E-09 |
| 2.D.3.d Urea Use | $CO_2$ | 0 | 0.817 | 20% | 10% | 0.2236 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.88868E-10 |
| 2.F.1. Refrigeration and air conditioning | HFCs | 0 | 206.3769351 | 50% | 50% | 0.7071 | 0.0001 | 0.0116 | 0.0116 | 0.0058 | 0.0082 | 0.000100428 |
| 2.F.2 Foam blowing agents | HFCs | 0 | 0.961490119 | 50% | 50% | 0.7071 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 2.17983E-09 |
| 2.F.3. Fire Protection | HFCs | 0 | 0.02767976 | 50% | 50% | 0.7071 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.80658E-12 |
| 2.F.4. Aerosols | HFCs | 0 | 4.697766137 | 50% | 50% | 0.7071 | 0.0000 | 0.0003 | 0.0003 | 0.0001 | 0.0002 | 5.20374E-08 |
| 2.G.1. Electrical equipment | SF6 | 0 | 8.577903643 | 2% | 30% | 0.3007 | 0.0000 | 0.0005 | 0.0005 | 0.0001 | 0.0000 | 2.10048E-08 |

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| 2.G.3. N2O from product uses | $N_2O$ | 1.30226 | 2.01448 | 2% | 2% | 0.0283 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 1.11752E-11 |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.989353 | 828.0431219 | 2% | 20% | 0.2010 | 0.0001 | 0.0572 | 0.0464 | 0.0114 | 0.0013 | 0.000132525 |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.92 | 18.5 | 2% | 50% | 0.5004 | 0.0000 | 0.0006 | 0.0010 | 0.0003 | 0.0000 | 8.32871E-08 |
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.54125 | 13.1025 | 2% | 20% | 0.2010 | 0.0000 | 0.0018 | 0.0007 | 0.0004 | 0.0000 | 1.3546E-07 |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.090525 | 13.021775 | 2% | 50% | 0.5004 | 0.0000 | 0.0002 | 0.0007 | 0.0001 | 0.0000 | 6.46656E-09 |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.9670107 | 70.59473241 | 25% | 20% | 0.3202 | 0.0000 | 0.0015 | 0.0040 | 0.0003 | 0.0014 | 2.04539E-06 |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 120.6657672 | 42.94734024 | 25% | 20% | 0.3202 | 0.0000 | 0.0035 | 0.0024 | 0.0007 | 0.0009 | 1.21446E-06 |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.78185 | 0.439375 | 25% | 30% | 0.3905 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.26051E-11 |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.824479542 | 2.221483039 | 25% | 30% | 0.3905 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 2.05121E-09 |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.37841625 | 20.64571937 | 25% | 20% | 0.3202 | 0.0000 | 0.0020 | 0.0012 | 0.0004 | 0.0004 | 3.34422E-07 |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 40.75322335 | 5.647103039 | 25% | 20% | 0.3202 | 0.0000 | 0.0017 | 0.0003 | 0.0003 | 0.0001 | 1.252E-07 |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.4845375 | 7.840283798 | 25% | 30% | 0.3905 | 0.0000 | 0.0002 | 0.0004 | 0.0001 | 0.0002 | 2.68054E-08 |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.98598703 | 11.52240459 | 25% | 30% | 0.3905 | 0.0000 | 0.0005 | 0.0006 | 0.0001 | 0.0002 | 7.2838E-08 |
| 3.B.5 Indirect N2O emissions from Manure Management | $N_2O$ | 137.5202478 | 41.93797066 | 2% | 30% | 0.3007 | 0.0000 | 0.0044 | 0.0024 | 0.0013 | 0.0001 | 1.73113E-06 |
| 3.D.1. Direct N2O emissions from managed soils | $N_2O$ | 1962.775641 | 1429.497775 | 2% | 50% | 0.5004 | 0.0021 | 0.0159 | 0.0802 | 0.0080 | 0.0023 | 6.8441E-05 |

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| 3.D.2 Indirect N2O Emissions from managed soils | $N_2O$ | 377.2229002 | 196.0440499 | 2% | 50% | 0.5004 | 0.0000 | 0.0075 | 0.0110 | 0.0037 | 0.0003 | 1.40548E-05 |
| 3.G. Liming | $CO_2$ | 371.4186667 | 19.68633333 | 2% | 50% | 0.5004 | 0.0000 | 0.0171 | 0.0011 | 0.0085 | 0.0000 | 7.28856E-05 |
| 3.H. Urea Application | $CO_2$ | 7.7088 | 4.726333333 | 20% | 50% | 0.5385 | 0.0000 | 0.0001 | 0.0003 | 0.0001 | 0.0001 | 8.77434E-09 |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass | $CO_2$ | -19117.24262 | -529.091989 | 2% | 3% | 0.0323 | 0.0000 | 0.9160 | 0.0297 | 0.0256 | 0.0007 | 0.000658261 |
| 4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood | $CO_2$ | 77.31120783 | -3792.439229 | 2% | 5% | 0.0499 | 0.0001 | 0.2164 | 0.2126 | 0.0102 | 0.0048 | 0.000127788 |
| 4.A.1 Forest Land remaining Forest Land – Drained organic soil | $CO_2$ | 4125.54896 | 4583.280676 | 5% | 25% | 0.2555 | 0.0057 | 0.0549 | 0.2570 | 0.0137 | 0.0192 | 0.000556639 |
| 4.A.2 Land converted to Forest Land – Carbon stock change, grassland converted to forest land | $CO_2$ | -0.15774 | -341.1744233 | 8% | 50% | 0.5044 | 0.0001 | 0.0191 | 0.0191 | 0.0095 | 0.0022 | 9.53919E-05 |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, dead wood | $CO_2$ | -1.612112333 | -83.797142 | 8% | | 0.0802 | 0.0000 | 0.0046 | 0.0047 | 0.0000 | 0.0005 | 2.83993E-07 |
| 4.A.2 Land Converted to Forest Land – grassland converted to forest land, carbon stock change, litter | $CO_2$ | -1.3821621 | -71.8444518 | 8% | | 0.0802 | 0.0000 | 0.0040 | 0.0040 | 0.0000 | 0.0005 | 2.08755E-07 |
| 4.A.2 Land converted to Forest Land – grassland converted to forest land, Drained organic soil | $CO_2$ | 0 | 61.24812203 | 44% | 25% | 0.5020 | 0.0000 | 0.0034 | 0.0034 | 0.0009 | 0.0021 | 5.20667E-06 |

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| 4.A.1 Forest land remaining forest land - Controlled burning | $CO_2$ | 256.17754 | 88.88382 | 92% | 6% | 0.9220 | 0.0000 | 0.0076 | 0.0050 | 0.0005 | 0.0065 | 4.22513E-05 |
| 4.A.1 Forest land remaining forest land - Controlled burning | $CH_4$ | 25.2045 | 8.745 | 92% | 36% | 0.9879 | 0.0000 | 0.0007 | 0.0005 | 0.0003 | 0.0006 | 4.78639E-07 |
| 4.A.1 Forest land remaining forest land - Controlled burning | $N_2O$ | 2.95616 | 1.02512 | 92% | | 0.9200 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0001 | 5.59276E-09 |
| 4.A.1 Forest land remaining forest land - wildfires | $CH_4$ | 2.525 | 9.198 | 37% | 36% | 0.5162 | 0.0000 | 0.0004 | 0.0005 | 0.0001 | 0.0003 | 9.27551E-08 |
| 4.A.1 Forest land remaining forest land - wildfires | $N_2O$ | 0.295616 | 1.078462 | 37% | | 0.3700 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 1.00118E-09 |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CO_2$ | 0 | 22.06783674 | 5% | 242% | 2.4206 | 0.0000 | 0.0012 | 0.0012 | 0.0030 | 0.0001 | 8.975E-06 |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 56.12604453 | 149.8529208 | 5% | 119% | 1.1862 | 0.0001 | 0.0057 | 0.0084 | 0.0067 | 0.0006 | 4.5297E-05 |
| 4.A.1. Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $N_2O$ | 567.421657 | 638.8013455 | 6% | 119% | 1.1928 | 0.0024 | 0.0080 | 0.0358 | 0.0096 | 0.0032 | 0.000101831 |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – living biomass | $CO_2$ | -6.124066667 | -8.288426667 | 3% | 701% | 7.0070 | 0.0000 | 0.0002 | 0.0005 | 0.0012 | 0.0000 | 1.33617E-06 |
| 4.B.1 Cropland remaining Cropland – Carbon stock change – dead organic matter | $CO_2$ | -1.368033333 | -1.2914 | 3% | | 0.0260 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 7.08875E-12 |

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| 4.B.1 Cropland remaining Cropland – Drained organic soil | $CO_2$ | 2761.364974 | 2598.776785 | 13% | 18% | 0.2270 | 0.0014 | 0.0105 | 0.1457 | 0.0019 | 0.0274 | 0.000754926 |
| 4.B.2 Land converted to Cropland – Carbon stock change, forest land converted to cropland | $CO_2$ | 373.3561333 | 21.17573333 | 53% | 161% | 1.6933 | 0.0000 | 0.0171 | 0.0012 | 0.0275 | 0.0009 | 0.000754684 |
| 4.B.1 Land converted to Cropland – Carbon stock change – dead organic matter | $CO_2$ | 147.0542333 | 8.696233333 | 53% | | 0.5337 | 0.0000 | 0.0067 | 0.0005 | 0.0000 | 0.0004 | 1.35443E-07 |
| 4.B.2 Land converted to Cropland –Mineral soil | $CO_2$ | 6.935133333 | 48.7498 | 64% | 61% | 0.8888 | 0.0000 | 0.0024 | 0.0027 | 0.0015 | 0.0025 | 8.35363E-06 |
| 4.B.2 Land converted to Cropland – Drained organic soil | $CO_2$ | 12.45566667 | 89.507 | 114% | 18% | 1.1533 | 0.0000 | 0.0044 | 0.0050 | 0.0008 | 0.0081 | 6.59533E-05 |
| 4.B.2 Wetlands converted to cropland, organic soil | $CO_2$ | 0 | 3.8236 | 114% | 18% | 1.1532 | 0.0000 | 0.0002 | 0.0002 | 0.0000 | 0.0003 | 1.20704E-07 |
| 4.B.2 Settlements converted to cropland, mineral soils | $CO_2$ | 0 | 5.310433333 | 64% | 60% | 0.8806 | 0.0000 | 0.0003 | 0.0003 | 0.0002 | 0.0003 | 1.05574E-07 |
| 4.B. Cropland remaining cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 125.0975756 | 119.0448062 | 13% | 71% | 0.7223 | 0.0000 | 0.0006 | 0.0067 | 0.0004 | 0.0013 | 1.72932E-06 |
| 4.B.2 Land converted to cropland, Direct nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or | $N_2O$ | 0.590489444 | 4.882747284 | 64% | 151% | 1.6390 | 0.0000 | 0.0002 | 0.0003 | 0.0004 | 0.0002 | 1.98448E-07 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| management of mineral soils | | | | | | | | | | | | |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – living biomass | $CO_2$ | -19.17968712 | -42.87716154 | 5% | 122% | 1.2220 | 0.0000 | 0.0015 | 0.0024 | 0.0018 | 0.0002 | 3.22954E-06 |
| 4.C.1 Grassland remaining Grassland – Carbon stock change – dead organic matter | $CO_2$ | -4.284491677 | -8.55723594 | 5% | | 0.0498 | 0.0000 | 0.0003 | 0.0005 | 0.0000 | 0.0000 | 1.1419E-09 |
| 4.C.1 Grassland remaining Grassland – Drained organic soil | $CO_2$ | 924.832656 | 684.0066031 | 26% | 19% | 0.3193 | 0.0002 | 0.0069 | 0.0384 | 0.0013 | 0.0140 | 0.000196621 |
| 4.C.2 Land converted to Grassland –Mineral soil | $CO_2$ | -0.0030613 | -495.2573527 | 10% | 61% | 0.6201 | 0.0004 | 0.0278 | 0.0278 | 0.0170 | 0.0039 | 0.000304122 |
| 4.C.2 Land converted to Grassland – Drained organic soil | $CO_2$ | 0.0008613 | 275.3924023 | 55% | 19% | 0.5825 | 0.0001 | 0.0154 | 0.0154 | 0.0029 | 0.0120 | 0.000153297 |
| 4.C. Grassland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils | $CH_4$ | 69.98791354 | 72.89522859 | 24% | 58% | 0.6294 | 0.0000 | 0.0007 | 0.0041 | 0.0004 | 0.0014 | 2.10429E-06 |
| 4.C.1 Grassland remaining Grassland, wildfires | $CH_4$ | 0.049609865 | 0.609294045 | 10% | 39% | 0.4026 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.76524E-10 |
| 4.C.1 Grassland remaining Grassland, wildfires | $N_2O$ | 0.053992802 | 0.663123844 | 10% | 48% | 0.4903 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.02499E-10 |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – living biomass | $CO_2$ | -65.31052768 | -165.2320183 | 6% | 435% | 4.3521 | 0.0021 | 0.0061 | 0.0093 | 0.0264 | 0.0008 | 0.000697828 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – dead organic matter | $CO_2$ | -13.80988549 | -29.46614791 | 6% | | 0.0590 | 0.0000 | 0.0010 | 0.0017 | 0.0000 | 0.0001 | 1.90043E-08 |
| 4.D.1 Wetlands remaining Wetlands – Carbon stock change – organic soils | $CO_2$ | 277.2 | 277.2 | 24% | 55% | 0.6042 | 0.0001 | 0.0020 | 0.0155 | 0.0011 | 0.0053 | 2.95581E-05 |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CO_2$ | 1016.928 | 899.740705 | 24% | | 0.2423 | 0.0002 | 0.0007 | 0.0504 | 0.0000 | 0.0173 | 0.000298843 |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $CH_4$ | 28.53444375 | 28.53444375 | 24% | 71% | 0.7512 | 0.0000 | 0.0002 | 0.0016 | 0.0001 | 0.0005 | 3.21425E-07 |
| 4.D.1. Wetlands, Peat extraction from lands, organic soils | $N_2O$ | 3.793114158 | 3.793114158 | 24% | 112% | 1.1459 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0001 | 6.22573E-09 |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – living biomass | $CO_2$ | -48.28378427 | -108.185671 | 9% | 389% | 3.8957 | 0.0007 | 0.0037 | 0.0061 | 0.0144 | 0.0007 | 0.000208496 |
| 4.E.1 Settlements remaining Settlements – Carbon stock change – dead organic matter | $CO_2$ | -6.10842148 | -10.61212032 | 9% | | 0.0867 | 0.0000 | 0.0003 | 0.0006 | 0.0000 | 0.0001 | 5.32284E-09 |
| 4.E.1 Settlements remaining Settlements – Drained organic soils | $CO_2$ | 0 | 19.43012935 | 9% | 18% | 0.2029 | 0.0000 | 0.0011 | 0.0011 | 0.0002 | 0.0001 | 5.77668E-08 |
| 4.E.2 Land converted to Settlements – Carbon stock change – living biomass | $CO_2$ | 115.9029234 | 480.9177105 | 20% | 295% | 2.9525 | 0.0083 | 0.0213 | 0.0270 | 0.0627 | 0.0075 | 0.003989798 |
| 4.E.2 Land converted to Settlements – Carbon stock change – dead organic matter | $CO_2$ | 45.65085251 | 197.4969716 | 20% | | 0.1960 | 0.0000 | 0.0088 | 0.0111 | 0.0000 | 0.0031 | 9.42181E-06 |
| 4.E.2 Land converted to | $CO_2$ | 1.399566667 | 107.2922807 | 22% | 60% | 0.6390 | 0.0000 | 0.0059 | 0.0060 | 0.0036 | 0.0019 | 1.62309E-05 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Settlements – Mineral soils | | | | | | | | | | | | |
| 4.E.2 Land converted to Settlements – Organic soils | $CO_2$ | 3.765666667 | 166.1761669 | 47% | 18% | 0.5049 | 0.0000 | 0.0091 | 0.0093 | 0.0017 | 0.0062 | 4.12272E-05 |
| 4.E.2 Lands converted to settlements, Direct nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0.910565999 | 40.47931849 | 20% | 38% | 0.4248 | 0.0000 | 0.0022 | 0.0023 | 0.0008 | 0.0006 | 1.09914E-06 |
| 4.E.2 Settlements remaining Settlements, Direct nitrous oxide (N2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils | $N_2O$ | 0 | 4.083489381 | 9% | 38% | 0.3867 | 0.0000 | 0.0002 | 0.0002 | 0.0001 | 0.0000 | 8.23522E-09 |
| 4. G. Harvested wood products | $CO_2$ | -166.3561979 | -1817.58 | 15% | 0% | 0.1500 | 0.0003 | 0.0938 | 0.1019 | 0.0000 | 0.0216 | 0.000467381 |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 0 | 301.0244136 | 7% | 52% | 0.5247 | 0.0001 | 0.0169 | 0.0169 | 0.0088 | 0.0017 | 7.98257E-05 |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 392.8311633 | 227.8019525 | 7% | 52% | 0.5247 | 0.0001 | 0.0065 | 0.0128 | 0.0034 | 0.0013 | 1.28679E-05 |
| 5.B.1. Composting | $CH_4$ | 23.90918253 | 22.4652 | 29% | 100% | 1.0412 | 0.0000 | 0.0001 | 0.0013 | 0.0001 | 0.0005 | 2.74842E-07 |
| 5.B.1. Composting | $N_2O$ | 17.09984734 | 16.06711104 | 29% | 90% | 0.9456 | 0.0000 | 0.0001 | 0.0009 | 0.0001 | 0.0004 | 1.39811E-07 |
| 5.C.1 Waste Incineration | $CO_2$ | 0.810707594 | 0.56263867 | 43% | 40% | 0.5873 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.7864E-10 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.C.1 Waste Incineration | $N_2O$ | 4.847024532 | 4.3807102 | 43% | 100% | 1.0885 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0001 | 2.23812E-08 |
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 109.5074001 | 45% | 30% | 0.5408 | 0.0000 | 0.0040 | 0.0061 | 0.0012 | 0.0039 | 1.67311E-05 |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687214 | 16.53660558 | 140% | 30% | 1.4318 | 0.0000 | 0.0003 | 0.0009 | 0.0001 | 0.0018 | 3.37728E-06 |
| 5.D.2 Industrial Wastewater | $CH_4$ | 137.025 | 138.525 | 64% | 30% | 0.7068 | 0.0000 | 0.0011 | 0.0078 | 0.0003 | 0.0070 | 4.95227E-05 |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.341428614 | 0.115643072 | 23% | 30% | 0.3780 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 1.05682E-09 |
| Total | | 17834.80 | 15573.52 | | | | 0.0253 | | | | | 0.0111 |
| Total Uncertainties | | | | | | Uncertainty in total inventory %: | 16% | | | | Trend uncertainty %: | 11% |

## A.2.2 Approach 1 uncertainty analysis for 2014 excluding LULUCF

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CO_2$ | 3049.621305 | 2.456340066 | 2% | 10% | 0.1020 | 0.0000 | 0.0501 | 0.0001 | 0.0050 | 0.0000 | 2.5071E-05 |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CO_2$ | 218.053 | 16.555 | 2% | 20% | 0.2010 | 0.0000 | 0.0030 | 0.0006 | 0.0006 | 0.0000 | 3.5084E-07 |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CO_2$ | 2644.318679 | 1575.698976 | 2% | 5% | 0.0539 | 0.0001 | 0.0164 | 0.0600 | 0.0008 | 0.0017 | 3.55744E-06 |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CO_2$ | 142.826737 | 0 | 2% | 10% | 0.1020 | 0.0000 | 0.0024 | 0.0000 | 0.0002 | 0.0000 | 5.53196E-08 |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $CO_2$ | 3.0786 | 0 | 2% | 20% | 0.2010 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 1.02819E-10 |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $CH_4$ | 3.00505 | 0.002425 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.09997E-10 |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $CH_4$ | 0.057625 | 0.004375 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.53048E-13 |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $CH_4$ | 1.20535 | 0.726 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.58219E-11 |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $CH_4$ | 0.327 | 8.434081116 | 5% | 50% | 0.5025 | 0.0000 | 0.0003 | 0.0003 | 0.0002 | 0.0000 | 2.54537E-08 |
| 1.A.1.a Public Electricity and Heat Production - Peat | $CH_4$ | 0.034425 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.03518E-14 |
| 1.A.1.a Public Electricity and Heat Production - Other fossil | $CH_4$ | 0.0315 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.72773E-14 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| fuels | | | | | | | | | | | | |
| 1.A.1.a Public Electricity and Heat Production - Liquid Fuels | $N_2O$ | 7.1626684 | 0.0057514 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 3.46562E-09 |
| 1.A.1.a Public Electricity and Heat Production - Solid Fuels | $N_2O$ | 1.030335 | 0.078225 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.89286E-11 |
| 1.A.1.a Public Electricity and Heat Production - Gaseous Fuels | $N_2O$ | 1.4367772 | 0.865392 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.24807E-11 |
| 1.A.1.a Public Electricity and Heat Production - Biomass Fuels | $N_2O$ | 0.519712 | 13.38625669 | 5% | 50% | 0.5025 | 0.0000 | 0.0005 | 0.0005 | 0.0003 | 0.0000 | 6.41172E-08 |
| 1.A.1.a Public Electricity and Heat Production - Peat | $N_2O$ | 0.615519 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.5688E-11 |
| 1.A.1.a Public Electricity and Heat Production - Other fossil fuels | $N_2O$ | 0.050064 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.69941E-13 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $CO_2$ | 24.7792529 | 21.16428627 | 2% | 10% | 0.1020 | 0.0000 | 0.0004 | 0.0008 | 0.0000 | 0.0000 | 2.10367E-09 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CO_2$ | 44.69904433 | 45.0354735 | 2% | 5% | 0.0539 | 0.0000 | 0.0010 | 0.0017 | 0.0000 | 0.0000 | 4.75004E-09 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CO_2$ | 73.83865681 | 0 | 2% | 10% | 0.1020 | 0.0000 | 0.0012 | 0.0000 | 0.0001 | 0.0000 | 1.4786E-08 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy | $CH_4$ | 0.02314 | 0.02145 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.80278E-14 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industries - Liquid Fuels | | | | | | | | | | | | |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $CH_4$ | 0.020375 | 0.02075 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.21961E-14 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $CH_4$ | 0 | 0.2955 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.22986E-11 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $CH_4$ | 0.0177725 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.14163E-14 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Liquid Fuels | $N_2O$ | 0.05379496 | 0.0511368 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.8482E-13 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels | $N_2O$ | 0.024287 | 0.024734 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.41635E-14 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Biomass Fuels | $N_2O$ | 0 | 0.469648 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.15856E-11 |
| 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat | $N_2O$ | 0.3177723 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.84667E-12 |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CO_2$ | 93.25228881 | 0 | 2% | 10% | 0.1020 | 0.0000 | 0.0015 | 0.0000 | 0.0002 | 0.0000 | 2.35828E-08 |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CO_2$ | 234.4643123 | 0.705374886 | 2% | 5% | 0.0539 | 0.0000 | 0.0038 | 0.0000 | 0.0002 | 0.0000 | 3.67507E-08 |
| 1.A.2.a Iron and Steel - Other | $CO_2$ | 61.3521 | 0 | 2% | 20% | 0.2010 | 0.0000 | 0.0010 | 0.0000 | 0.0002 | 0.0000 | 4.08325E-08 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| fossil fuels | | | | | | | | | | | | |
| 1.A.2.a Iron and Steel - Liquid Fuels | $CH_4$ | 0.091425 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.66732E-13 |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $CH_4$ | 0.106875 | 0.000325 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.63607E-13 |
| 1.A.2.a Iron and Steel - Other fossil fuels | $CH_4$ | 0.62775 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.6719E-11 |
| 1.A.2.a Iron and Steel - Liquid Fuels | $N_2O$ | 0.2179572 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.22099E-12 |
| 1.A.2.a Iron and Steel - Gaseous Fuels | $N_2O$ | 0.127395 | 0.0003874 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.08498E-12 |
| 1.A.2.a Iron and Steel - Other fossil fuels | $N_2O$ | 0.997704 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.74918E-11 |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CO_2$ | 0 | 3.906691677 | 2% | 5% | 0.0539 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 7.30568E-11 |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $CH_4$ | 0 | 0.0018 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.17869E-15 |
| 1.A.2.b Non-Ferrous Metals - Gaseous Fuels | $N_2O$ | 0 | 0.0021456 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.67476E-15 |
| 1.A.2.c Chemicals - Liquid Fuels | $CO_2$ | 276.6786727 | 10.10088453 | 2% | 10% | 0.1020 | 0.0000 | 0.0042 | 0.0004 | 0.0004 | 0.0000 | 1.74119E-07 |
| 1.A.2.c Chemicals - Gaseous Fuels | $CO_2$ | 23.42449305 | 17.14603569 | 2% | 5% | 0.0539 | 0.0000 | 0.0003 | 0.0007 | 0.0000 | 0.0000 | 5.19712E-10 |
| 1.A.2.c Chemicals - Peat | $CO_2$ | 0 | 1.12172959 | 2% | 11% | 0.1109 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.31812E-11 |
| 1.A.2.c Chemicals - Liquid Fuels | $CH_4$ | 0.273195 | 0.004725 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.6638E-12 |
| 1.A.2.c Chemicals - Gaseous | $CH_4$ | 0.0106775 | 0.0079 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.98094E-15 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuels | | | | | | | | | | | | |
| 1.A.2.c Chemicals - Biomass Fuels | $CH_4$ | 0 | 0.211451058 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.65382E-11 |
| 1.A.2.c Chemicals - Peat | $CH_4$ | 0 | 0.000521299 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.88619E-17 |
| 1.A.2.c Chemicals - Liquid Fuels | $N_2O$ | 0.65129688 | 0.0069732 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.73545E-11 |
| 1.A.2.c Chemicals - Gaseous Fuels | $N_2O$ | 0.01272758 | 0.0094168 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.65638E-15 |
| 1.A.2.c Chemicals - Biomass Fuels | $N_2O$ | 0 | 0.334983061 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.15063E-11 |
| 1.A.2.c Chemicals - Peat | $N_2O$ | 0 | 0.004850822 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.56025E-15 |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CO_2$ | 15.54739345 | 0.397748377 | 2% | 10% | 0.1020 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 5.80474E-10 |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CO_2$ | 2.692316 | 0 | 2% | 20% | 0.2010 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.86355E-11 |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CO_2$ | 149.4154681 | 5.263181843 | 2% | 5% | 0.0539 | 0.0000 | 0.0023 | 0.0002 | 0.0001 | 0.0000 | 1.28019E-08 |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $CH_4$ | 0.015225 | 0.00025 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.45458E-14 |
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $CH_4$ | 0.0007115 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.43239E-17 |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $CH_4$ | 0.0681075 | 0.002425 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.64856E-13 |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $CH_4$ | 0 | 0.00225 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.87255E-15 |
| 1.A.2.d. Pulp, Paper and Print - Liquid Fuels | $N_2O$ | 0.0362964 | 0.0004768 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.39807E-14 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.d. Pulp, Paper and Print - Solid Fuels | $N_2O$ | 0.01272162 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.09732E-14 |
| 1.A.2.d. Pulp, Paper and Print - Gaseous Fuels | $N_2O$ | 0.08118414 | 0.0028906 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.76324E-13 |
| 1.A.2.d. Pulp, Paper and Print - Biomass Fuels | $N_2O$ | 0 | 0.003576 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.73003E-15 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CO_2$ | 798.2058686 | 26.17773966 | 2% | 11% | 0.1111 | 0.0000 | 0.0121 | 0.0010 | 0.0013 | 0.0000 | 1.76147E-06 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CO_2$ | 103.071464 | 2.2704 | 2% | 20% | 0.2010 | 0.0000 | 0.0016 | 0.0001 | 0.0003 | 0.0000 | 1.03806E-07 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CO_2$ | 174.2220665 | 93.81485986 | 2% | 5% | 0.0539 | 0.0000 | 0.0007 | 0.0036 | 0.0000 | 0.0001 | 1.14515E-08 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CO_2$ | 0 | 2.1257 | 2% | 20% | 0.2010 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 2.67419E-10 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $CH_4$ | 0.78871 | 0.02035 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.72948E-11 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $CH_4$ | 0.026721 | 0.0006 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.3515E-14 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $CH_4$ | 0.079415 | 0.043225 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.07998E-14 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $CH_4$ | 0.171 | 0.3505 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.8627E-11 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $CH_4$ | 0 | 0.02175 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.72097E-13 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels | $N_2O$ | 1.87891384 | 0.0437464 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.14284E-10 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels | $N_2O$ | 0.47777148 | 0.010728 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.39115E-11 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels | $N_2O$ | 0.09466268 | 0.0515242 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.37623E-14 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Biomass Fuels | $N_2O$ | 0.271776 | 0.556962 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.22788E-11 |
| 1.A.2.e Food Processing, Beverages and Tobacco - Other Fossil Fuels | $N_2O$ | 0 | 0.034568 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.34715E-13 |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CO_2$ | 273.5769252 | 20.35027526 | 2% | 10% | 0.1020 | 0.0000 | 0.0037 | 0.0008 | 0.0004 | 0.0000 | 1.39606E-07 |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CO_2$ | 16.4292 | 118.6284 | 2% | 20% | 0.2010 | 0.0000 | 0.0042 | 0.0045 | 0.0008 | 0.0001 | 7.37973E-07 |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CO_2$ | 314.4838285 | 73.41324777 | 2% | 5% | 0.0539 | 0.0000 | 0.0024 | 0.0028 | 0.0001 | 0.0001 | 2.04482E-08 |
| 1.A.2.f Non-metallic Minerals - | $CO_2$ | 0 | 107.5693 | 2% | 2% | 0.0283 | 0.0000 | 0.0041 | 0.0041 | 0.0001 | 0.0001 | 2.01412E-08 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Other Fossil Fuels | | | | | | | | | | | | |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $CH_4$ | 0.268845 | 0.020625 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.31644E-12 |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $CH_4$ | 0.00425 | 0.03135 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.16986E-13 |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $CH_4$ | 0.14335 | 0.033825 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.88893E-13 |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $CH_4$ | 0.00525 | 0.949410006 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.31847E-10 |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $CH_4$ | 0 | 0.937280723 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.19592E-10 |
| 1.A.2.f Non-metallic Minerals - Liquid Fuels | $N_2O$ | 0.64092648 | 0.04917 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.88489E-11 |
| 1.A.2.f Non-metallic Minerals - Solid Fuels | $N_2O$ | 0.07599 | 0.560538 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.01339E-10 |
| 1.A.2.f Non-metallic Minerals - Gaseous Fuels | $N_2O$ | 0.1708732 | 0.0403194 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.10478E-13 |
| 1.A.2.f Non-metallic Minerals - Biomass Fuels | $N_2O$ | 0.008344 | 1.509107769 | 5% | 50% | 0.5025 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 8.38438E-10 |
| 1.A.2.f Non-metallic Minerals - Other Fossil Fuels | $N_2O$ | 0 | 1.489651495 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 8.07282E-10 |
| 1.A.2.g Other - Liquid Fuels | $CO_2$ | 795.7039841 | 104.8142275 | 2% | 10% | 0.1020 | 0.0000 | 0.0091 | 0.0040 | 0.0009 | 0.0001 | 8.42549E-07 |
| 1.A.2.g Other - Solid Fuels | $CO_2$ | 27.263264 | 5.4868 | 2% | 20% | 0.2010 | 0.0000 | 0.0002 | 0.0002 | 0.0000 | 0.0000 | 2.33918E-09 |
| 1.A.2.g Other - Gaseous Fuels | $CO_2$ | 524.168965 | 91.04761992 | 2% | 5% | 0.0539 | 0.0000 | 0.0052 | 0.0035 | 0.0003 | 0.0001 | 7.62768E-08 |
| 1.A.2.g Other - Peat | $CO_2$ | 0 | 1.331164465 | 2% | 10% | 0.1020 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 2.77598E-11 |
| 1.A.2.g Other - Liquid Fuels | $CH_4$ | 2.26531 | 0.173975 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.35354E-10 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.2.g Other - Solid Fuels | $CH_4$ | 0.006946 | 0.00145 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.77581E-16 |
| 1.A.2.g Other - Gaseous Fuels | $CH_4$ | 0.23893 | 0.04195 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.36757E-12 |
| 1.A.2.g Other - Biomass Fuels | $CH_4$ | 0.2865 | 10.965 | 5% | 50% | 0.5025 | 0.0000 | 0.0004 | 0.0004 | 0.0002 | 0.0000 | 4.34923E-08 |
| 1.A.2.g Other - Peat | $CH_4$ | 0 | 0.000575 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.2028E-16 |
| 1.A.2.g Other - Liquid Fuels | $N_2O$ | 2.149772 | 0.252487056 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.6632E-10 |
| 1.A.2.g Other - Solid Fuels | $N_2O$ | 0.12419448 | 0.025926 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.80558E-13 |
| 1.A.2.g Other - Gaseous Fuels | $N_2O$ | 0.28480456 | 0.0500044 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.94313E-12 |
| 1.A.2.g Other - Biomass Fuels | $N_2O$ | 0.455344 | 17.42704 | 5% | 50% | 0.5025 | 0.0000 | 0.0007 | 0.0007 | 0.0003 | 0.0000 | 1.09861E-07 |
| 1.A.2.g Other - Peat | $N_2O$ | 0 | 0.005811 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.22845E-14 |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CO_2$ | 0.011005031 | 0.28 | 2% | 5% | 0.0539 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.65701E-13 |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CO_2$ | 0.054819072 | 3.13427 | 2% | 5% | 0.0539 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 4.64867E-11 |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $CH_4$ | 1.96519E-06 | 0.00005 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.78933E-19 |
| 1.A.3.a Domestic Aviation - Jet kerosene | $CH_4$ | 0.000009504 | 0.0021375 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.65578E-15 |
| 1.A.3.a Domestic Aviation - Aviation Gasoline | $N_2O$ | 9.36998E-05 | 0.002384 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.99815E-15 |
| 1.A.3.a Domestic Aviation - Jet kerosene | $N_2O$ | 0.000453151 | 0.029353 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.09287E-13 |
| 1.A.3.b Road Transportation - Gasoline | $CO_2$ | 1723.750448 | 613.35806 | 2% | 2% | 0.0283 | 0.0000 | 0.0050 | 0.0234 | 0.0001 | 0.0007 | 4.46659E-07 |
| 1.A.3.b Road Transportation - Diesel Oil | $CO_2$ | 616.1359677 | 1880.266 | 2% | 2% | 0.0283 | 0.0000 | 0.0615 | 0.0716 | 0.0012 | 0.0020 | 5.61304E-06 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.b Road Transportation - LPG | $CO_2$ | 36.95737306 | 165.2425801 | 2% | 5% | 0.0539 | 0.0000 | 0.0057 | 0.0063 | 0.0003 | 0.0002 | 1.12475E-07 |
| 1.A.3.b Road Transportation - Lubricants | $CO_2$ | 3.4629 | 4.554798669 | 10% | 5% | 0.1118 | 0.0000 | 0.0001 | 0.0002 | 0.0000 | 0.0000 | 6.3576E-10 |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CO_2$ | 17.6165255 | 0 | 2% | 5% | 0.0539 | 0.0000 | 0.0003 | 0.0000 | 0.0000 | 0.0000 | 2.10418E-10 |
| 1.A.3.b Road Transportation - Gasoline | $CH_4$ | 17.15516309 | 2.207274532 | 2% | 30% | 0.3007 | 0.0000 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 3.55015E-09 |
| 1.A.3.b Road Transportation - Diesel Oil | $CH_4$ | 1.108041461 | 1.356526416 | 2% | 30% | 0.3007 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 1.02636E-10 |
| 1.A.3.b Road Transportation - LPG | $CH_4$ | 0.124565463 | 0.863788568 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.38746E-10 |
| 1.A.3.b Road Transportation - Lubricants | $CH_4$ | 0.02475 | 0.014988474 | 10% | 50% | 0.5099 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.31804E-14 |
| 1.A.3.b Road Transportation - Gaseous Fuels | $CH_4$ | 0.7015 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.33659E-11 |
| 1.A.3.b Road Transportation - Biomass | $CH_4$ | 0 | 0.023009615 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.92608E-13 |
| 1.A.3.b Road Transportation - Gasoline | $N_2O$ | 13.07410741 | 4.606850327 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 4.21725E-10 |
| 1.A.3.b Road Transportation - Diesel Oil | $N_2O$ | 5.593827044 | 19.44722022 | 2% | 50% | 0.5004 | 0.0000 | 0.0006 | 0.0007 | 0.0003 | 0.0000 | 1.0559E-07 |
| 1.A.3.b Road Transportation - LPG | $N_2O$ | 0.163685304 | 2.934347457 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 2.9836E-09 |
| 1.A.3.b Road Transportation - Lubricants | $N_2O$ | 0.02384 | 0.032918912 | 10% | 50% | 0.5099 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.16827E-13 |
| 1.A.3.b Road Transportation - Gaseous Fuels | $N_2O$ | 0.27267 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.04106E-12 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.b Road Transportation - Biomass | $N_2O$ | 0 | 0.349076786 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.433E-11 |
| 1.A.3.c Railways - Liquid Fuels | $CO_2$ | 531.37994 | 213.786 | 2% | 5% | 0.0539 | 0.0000 | 0.0006 | 0.0081 | 0.0000 | 0.0002 | 5.3963E-08 |
| 1.A.3.c Railways - Liquid Fuels | $CH_4$ | 0.745009038 | 0.299750179 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.86132E-13 |
| 1.A.3.c. Railway Biomass Fuels | $CH_4$ | 0 | 0.0022825 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.8953E-15 |
| 1.A.3.c Railways - Liquid Fuels | $N_2O$ | 61.20060747 | 24.62371876 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0009 | 0.0000 | 0.0000 | 1.93082E-09 |
| 1.A.3.c. Railway Biomass Fuels | $N_2O$ | 0 | 0.0346276 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.36215E-13 |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CO_2$ | 0.172771761 | 0.3465 | 20% | 5% | 0.2062 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.42003E-11 |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CO_2$ | 0.8332289 | 12.58 | 2% | 5% | 0.0539 | 0.0000 | 0.0005 | 0.0005 | 0.0000 | 0.0000 | 7.25135E-10 |
| 1.A.3.d Domestic Naviagtion - Gasoline | $CH_4$ | 0.00295205 | 0.005924494 | 20% | 50% | 0.5385 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.19074E-14 |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $CH_4$ | 0.001126 | 0.017 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.92195E-14 |
| 1.A.3.d Domestic Naviagtion - Gasoline | $N_2O$ | 0.000219506 | 0.000440227 | 20% | 50% | 0.5385 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.57297E-17 |
| 1.A.3.d Domestic Naviagtion - Diesel Oil | $N_2O$ | 0.1006644 | 1.5198 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 7.92998E-10 |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CO_2$ | 1007.294341 | 155.5621374 | 2% | 10% | 0.1020 | 0.0000 | 0.0107 | 0.0059 | 0.0011 | 0.0002 | 1.1644E-06 |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CO_2$ | 1410.784936 | 38.5022 | 2% | 20% | 0.2010 | 0.0000 | 0.0218 | 0.0015 | 0.0044 | 0.0000 | 1.89337E-05 |
| 1.A.4.a | $CO_2$ | 334.0088098 | 238.7965288 | 2% | 5% | 0.0539 | 0.0000 | 0.0036 | 0.0091 | 0.0002 | 0.0003 | 9.84588E-08 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial/Institutional - Gaseous Fuels | | | | | | | | | | | | |
| 1.A.4.a Commercial/Institutional - Peat | $CO_2$ | 66.54499789 | 1.136164465 | 2% | 11% | 0.1109 | 0.0000 | 0.0011 | 0.0000 | 0.0001 | 0.0000 | 1.31871E-08 |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $CH_4$ | 3.495 | 0.649625 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.69709E-10 |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $CH_4$ | 3.72829 | 0.10175 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 8.27264E-10 |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $CH_4$ | 0.76125 | 0.550125 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.80558E-11 |
| 1.A.4.a Commercial/Institutional - Biomass Fuels | $CH_4$ | 39.135 | 34.97326278 | 5% | 50% | 0.5025 | 0.0000 | 0.0007 | 0.0013 | 0.0003 | 0.0001 | 1.27029E-07 |
| 1.A.4.a Commercial/Institutional - Peat | $CH_4$ | 0.168 | 0.00275 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.77153E-12 |
| 1.A.4.a Commercial/Institutional - Liquid Fuels | $N_2O$ | 2.411706848 | 0.369840648 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.64401E-10 |
| 1.A.4.a Commercial/Institutional - Solid Fuels | $N_2O$ | 6.66618252 | 0.181929 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 2.64471E-09 |
| 1.A.4.a Commercial/Institutional - Gaseous Fuels | $N_2O$ | 0.181482 | 0.1311498 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.02619E-12 |
| 1.A.4.a | $N_2O$ | 6.219856 | 5.564080248 | 5% | 50% | 0.5025 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 | 3.22106E-09 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial/Institutional - Biomass Fuels | | | | | | | | | | | | |
| 1.A.4.a Commercial/Institutional - Peat | $N_2O$ | 0.2955862 | 0.004619 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.5036E-12 |
| 1.A.4.b Residential - Liquid Fuels | $CO_2$ | 329.9110639 | 157.1324033 | 2% | 10% | 0.1020 | 0.0000 | 0.0006 | 0.0060 | 0.0001 | 0.0002 | 3.16912E-08 |
| 1.A.4.b Residential - Solid Fuels | $CO_2$ | 605.8184 | 50.2326 | 2% | 20% | 0.2010 | 0.0000 | 0.0081 | 0.0019 | 0.0016 | 0.0001 | 2.6027E-06 |
| 1.A.4.b Residential - Gaseous Fuels | $CO_2$ | 219.6011945 | 230.7118474 | 2% | 5% | 0.0539 | 0.0000 | 0.0052 | 0.0088 | 0.0003 | 0.0002 | 1.28588E-07 |
| 1.A.4.b Residential - Peat | $CO_2$ | 42.27150449 | 0 | 2% | 10% | 0.1020 | 0.0000 | 0.0007 | 0.0000 | 0.0001 | 0.0000 | 4.84606E-09 |
| 1.A.4.b Residential - Liquid Fuels | $CH_4$ | 0.868375 | 1.276125 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.96039E-10 |
| 1.A.4.b Residential - Solid Fuels | $CH_4$ | 48.03 | 3.9825 | 2% | 50% | 0.5004 | 0.0000 | 0.0006 | 0.0002 | 0.0003 | 0.0000 | 1.02192E-07 |
| 1.A.4.b Residential - Gaseous Fuels | $CH_4$ | 0.5005 | 0.5315 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.63289E-11 |
| 1.A.4.b Residential - Biomass Fuels | $CH_4$ | 96.42474185 | 101.6540154 | 10% | 10% | 0.1414 | 0.0000 | 0.0023 | 0.0039 | 0.0002 | 0.0005 | 3.51929E-07 |
| 1.A.4.b Residential - Peat | $CH_4$ | 3.1875 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 6.88885E-10 |
| 1.A.4.b Residential - Liquid Fuels | $N_2O$ | 0.4500694 | 0.344594088 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.29514E-12 |
| 1.A.4.b Residential - Solid Fuels | $N_2O$ | 2.862588 | 0.237357 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.63016E-10 |
| 1.A.4.b Residential - Gaseous Fuels | $N_2O$ | 0.1193192 | 0.1267096 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.06474E-12 |
| 1.A.4.b Residential - Biomass | $N_2O$ | 8.94447 | 10.597476 | 10% | 30% | 0.3162 | 0.0000 | 0.0003 | 0.0004 | 0.0001 | 0.0001 | 9.1707E-09 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuels | | | | | | | | | | | | |
| 1.A.4.b Residential - Peat | $N_2O$ | 0.1860712 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.3475E-12 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CO_2$ | 695.0757089 | 320.5751539 | 2% | 11% | 0.1088 | 0.0000 | 0.0008 | 0.0122 | 0.0001 | 0.0003 | 1.25897E-07 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CO_2$ | 102.28152 | 2.2704 | 2% | 50% | 0.5004 | 0.0000 | 0.0016 | 0.0001 | 0.0008 | 0.0000 | 6.38319E-07 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CO_2$ | 778.5312078 | 55.18201994 | 2% | 50% | 0.5004 | 0.0000 | 0.0107 | 0.0021 | 0.0054 | 0.0001 | 2.87138E-05 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $CO_2$ | 3.0225 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.19411E-10 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $CH_4$ | 5.286318275 | 0.590724755 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 1.04238E-09 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $CH_4$ | 8.109 | 0.18 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 4.01245E-09 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $CH_4$ | 1.774375 | 0.127125 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.4861E-10 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $CH_4$ | 9.15 | 2.625286653 | 5% | 50% | 0.5025 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 6.92612E-10 |
| 1.A.4.c Agriculture/Forestry/Fisheries - | $CH_4$ | 0.2325 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.66516E-12 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peat | | | | | | | | | | | | |
| 1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels | $N_2O$ | 43.26924002 | 33.54418198 | 2% | 50% | 0.5004 | 0.0000 | 0.0006 | 0.0013 | 0.0003 | 0.0000 | 8.11041E-08 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels | $N_2O$ | 0.4832964 | 0.010728 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.42529E-11 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels | $N_2O$ | 0.423011 | 0.0303066 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.44619E-12 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Biomass Fuels | $N_2O$ | 1.45424 | 0.431444174 | 5% | 50% | 0.5025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.54771E-11 |
| 1.A.4.c Agriculture/Forestry/Fisheries - Peat | $N_2O$ | 0.013857 | 0 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.30193E-14 |
| 1.A.5.b Mobile - Liquid Fuels | $CO_2$ | 0 | 9.442494289 | 2% | 50% | 0.5004 | 0.0000 | 0.0004 | 0.0004 | 0.0002 | 0.0000 | 3.24362E-08 |
| 1.A.5.b Mobile - Liquid Fuels | $CH_4$ | 0 | 0.018743571 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.27809E-13 |
| 1.A.5.b Mobile - Liquid Fuels | $N_2O$ | 0 | 0.076423393 | 2% | 50% | 0.5004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.12475E-12 |
| 1.B.2.b Natural Gas | $CO_2$ | 0.008686 | 0.011105 | 32% | 0% | 0.3224 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.71808E-14 |
| 1.B.2.b Natural Gas | $CH_4$ | 177.238 | 109.190125 | 32% | 0% | 0.3224 | 0.0000 | 0.0012 | 0.0042 | 0.0000 | 0.0019 | 3.59458E-06 |
| 1.B.2.c Venting and Flaring | $CO_2$ | 0.002806 | 0.002657 | 10% | 0% | 0.1000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.04805E-16 |
| 1.B.2.c Venting and Flaring | $CH_4$ | 70.344325 | 26.126175 | 10% | 0% | 0.1000 | 0.0000 | 0.0002 | 0.0010 | 0.0000 | 0.0001 | 1.9802E-08 |
| 2.A.1. Cement Production | $CO_2$ | 370.8039966 | 555.775815 | 10% | 5% | 0.1118 | 0.0000 | 0.0151 | 0.0212 | 0.0008 | 0.0030 | 9.52792E-06 |
| 2.A.2. Lime Production | $CO_2$ | 148.8573814 | 0.459881348 | 2% | 50% | 0.5004 | 0.0000 | 0.0024 | 0.0000 | 0.0012 | 0.0000 | 1.48085E-06 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.A.3. Glass production | $CO_2$ | 0.355752064 | 0.942744575 | 2% | 86% | 0.8602 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.6874E-10 |
| 2.A.4. Other process uses of carbonates | $CO_2$ | 69.184752 | 10.8326905 | 2% | 50% | 0.5004 | 0.0000 | 0.0007 | 0.0004 | 0.0004 | 0.0000 | 1.32187E-07 |
| 2.C.1 Iron and Steel Production | $CO_2$ | 52.59606386 | 0.01036233 | 5% | 25% | 0.2550 | 0.0000 | 0.0009 | 0.0000 | 0.0002 | 0.0000 | 4.68469E-08 |
| 2.C.1 Iron and Steel Production | $CH_4$ | 0.06875 | 1.15638E-05 | 10% | 25% | 0.2693 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.00562E-14 |
| 2.D.1 Lubricant Use | $CO_2$ | 23.25102433 | 8.297813333 | 2% | 50% | 0.5004 | 0.0000 | 0.0001 | 0.0003 | 0.0000 | 0.0000 | 1.1981E-09 |
| 2.D.2 Paraffin wax use | $CO_2$ | 0 | 4.911573333 | 2% | 100% | 1.0002 | 0.0000 | 0.0002 | 0.0002 | 0.0002 | 0.0000 | 3.50201E-08 |
| 2.D.3.b Road paving with asphalt | $CO_2$ | 0.001463305 | 0.054450618 | 20% | 60% | 0.6325 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.85651E-12 |
| 2.D.3.c Asphalt roofing | $CO_2$ | 0.002972338 | 0.049156808 | 20% | 60% | 0.6325 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.47711E-12 |
| 2.D.3. Solvent Use | $CO_2$ | 41.0641984 | 32.19721064 | 2% | 20% | 0.2010 | 0.0000 | 0.0005 | 0.0012 | 0.0001 | 0.0000 | 1.33023E-08 |
| 2.D.3.d Urea Use | $CO_2$ | 0 | 0.817 | 20% | 10% | 0.2236 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.71395E-11 |
| 2.F.1. Refrigeration and air conditioning | HFCs | 0 | 206.3769351 | 50% | 50% | 0.7071 | 0.0002 | 0.0079 | 0.0079 | 0.0039 | 0.0056 | 4.63353E-05 |
| 2.F.2 Foam blowing agents | HFCs | 0 | 0.961490119 | 50% | 50% | 0.7071 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.00573E-09 |
| 2.F.3. Fire Protection | HFCs | 0 | 0.02767976 | 50% | 50% | 0.7071 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.33517E-13 |
| 2.F.4. Aerosols | HFCs | 0 | 4.697766137 | 50% | 50% | 0.7071 | 0.0000 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 2.40089E-08 |
| 2.G.1. Electrical equipment | SF6 | 0 | 8.577903643 | 2% | 30% | 0.3007 | 0.0000 | 0.0003 | 0.0003 | 0.0001 | 0.0000 | 9.69118E-09 |
| 2.G.3. N2O from product uses | $N_2O$ | 1.30226 | 2.01448 | 2% | 2% | 0.0283 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 5.93139E-12 |
| 3.A.1 Enteric Fermentation - Cattle | $CH_4$ | 2117.989353 | 828.0431219 | 2% | 20% | 0.2010 | 0.0002 | 0.0033 | 0.0315 | 0.0007 | 0.0009 | 1.24205E-06 |
| 3.A.2 Enteric Fermentation - Sheep | $CH_4$ | 32.92 | 18.5 | 2% | 50% | 0.5004 | 0.0000 | 0.0002 | 0.0007 | 0.0001 | 0.0000 | 6.9942E-09 |

| IPCC category/Group | Gas | Base year emissions or removals | Year 2014 emissions or removals | Activity data uncertainty | Emission factor / estimation parameter uncertainty | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty | Uncertainty in trend in national emissions introduced by activity data uncertainty | Uncertainty introduced into the trend in total national emissions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.A.3 Enteric Fermentation - Swine | $CH_4$ | 52.54125 | 13.1025 | 2% | 20% | 0.2010 | 0.0000 | 0.0004 | 0.0005 | 0.0001 | 0.0000 | 5.5647E-09 |
| 3.A.4 Enteric Fermentation - Other livestock | $CH_4$ | 18.090525 | 13.021775 | 2% | 50% | 0.5004 | 0.0000 | 0.0002 | 0.0005 | 0.0001 | 0.0000 | 9.99985E-09 |
| 3.B.1.1 Manure Management - Cattle | $CH_4$ | 110.9670107 | 70.59473241 | 25% | 20% | 0.3202 | 0.0000 | 0.0009 | 0.0027 | 0.0002 | 0.0010 | 9.33279E-07 |
| 3.B.2.1 Manure Management - Cattle | $N_2O$ | 120.6657672 | 42.94734024 | 25% | 20% | 0.3202 | 0.0000 | 0.0004 | 0.0016 | 0.0001 | 0.0006 | 3.39376E-07 |
| 3.B.1.2 Manure Management - Sheep | $CH_4$ | 0.78185 | 0.439375 | 25% | 30% | 0.3905 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.6343E-11 |
| 3.B.2.2 Manure Management - Sheep | $N_2O$ | 1.824479542 | 2.221483039 | 25% | 30% | 0.3905 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 1.16272E-09 |
| 3.B.1.3 Manure Management - Swaine | $CH_4$ | 65.37841625 | 20.64571937 | 25% | 20% | 0.3202 | 0.0000 | 0.0003 | 0.0008 | 0.0001 | 0.0003 | 8.06581E-08 |
| 3.B.2.3 Manure Management - Swaine | $N_2O$ | 40.75322335 | 5.647103039 | 25% | 20% | 0.3202 | 0.0000 | 0.0005 | 0.0002 | 0.0001 | 0.0001 | 1.41019E-08 |
| 3.B.1.4 Manure Management - Other livestock | $CH_4$ | 12.4845375 | 7.840283798 | 25% | 30% | 0.3905 | 0.0000 | 0.0001 | 0.0003 | 0.0000 | 0.0001 | 1.1924E-08 |
| 3.B.2.4 Manure Management - Other livestock | $N_2O$ | 22.98598703 | 11.52240459 | 25% | 30% | 0.3905 | 0.0000 | 0.0001 | 0.0004 | 0.0000 | 0.0002 | 2.43999E-08 |
| 3.B.5 Indirect N2O emissions from Manure Management | $N_2O$ | 137.5202478 | 41.93797066 | 2% | 30% | 0.3007 | 0.0000 | 0.0007 | 0.0016 | 0.0002 | 0.0000 | 4.21375E-08 |
| 3.D.1. Direct N2O emissions from managed soils | $N_2O$ | 1962.775641 | 1429.497775 | 2% | 50% | 0.5004 | 0.0040 | 0.0221 | 0.0544 | 0.0111 | 0.0015 | 0.00012451 |
| 3.D.2 Indirect N2O Emissions from managed soils | $N_2O$ | 377.2229002 | 196.0440499 | 2% | 50% | 0.5004 | 0.0001 | 0.0013 | 0.0075 | 0.0006 | 0.0002 | 4.37755E-07 |
| 3.G. Liming | $CO_2$ | 371.4186667 | 19.68633333 | 2% | 50% | 0.5004 | 0.0000 | 0.0054 | 0.0007 | 0.0027 | 0.0000 | 7.19941E-06 |

| **IPCC category/Group** | **Gas** | **Base year emissions or removals** | **Year 2014 emissions or removals** | **Activity data uncertainty** | **Emission factor / estimation parameter uncertainty** | **Combined uncertainty** | **Contribution to variance by category in year x** | **Type A sensitivity** | **Type B sensitivity** | **Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty** | **Uncertainty in trend in national emissions introduced by activity data uncertainty** | **Uncertainty introduced into the trend in total national emissions** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.H. Urea Application | $CO_2$ | 7.7088 | 4.726333333 | 20% | 50% | 0.5385 | 0.0000 | 0.0001 | 0.0002 | 0.0000 | 0.0001 | 3.29588E-09 |
| 5.A.1. Managed Waste Disposal on Land | $CH_4$ | 0 | 301.0244136 | 7% | 52% | 0.5247 | 0.0002 | 0.0115 | 0.0115 | 0.0060 | 0.0011 | 3.68299E-05 |
| 5.A.2. Unmanaged Waste Disposal Sites | $CH_4$ | 392.8311633 | 227.8019525 | 7% | 52% | 0.5247 | 0.0001 | 0.0022 | 0.0087 | 0.0011 | 0.0009 | 2.05402E-06 |
| 5.B.1. Composting | $CH_4$ | 23.90918253 | 22.4652 | 29% | 100% | 1.0412 | 0.0000 | 0.0005 | 0.0009 | 0.0005 | 0.0004 | 3.36443E-07 |
| 5.B.1. Composting | $N_2O$ | 17.09984734 | 16.06711104 | 29% | 90% | 0.9456 | 0.0000 | 0.0003 | 0.0006 | 0.0003 | 0.0003 | 1.51364E-07 |
| 5.C.1 Waste Incineration | $CO_2$ | 0.810707594 | 0.56263867 | 43% | 40% | 0.5873 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.80246E-10 |
| 5.C.1 Waste Incineration | $N_2O$ | 4.847024532 | 4.3807102 | 43% | 100% | 1.0885 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 1.78665E-08 |
| 5.D.1 Domestic Wastewater | $CH_4$ | 207.775 | 109.5074001 | 45% | 30% | 0.5408 | 0.0000 | 0.0007 | 0.0042 | 0.0002 | 0.0027 | 7.0953E-06 |
| 5.D.1 Domestic Wastewater | $N_2O$ | 24.687214 | 16.53660558 | 140% | 30% | 1.4318 | 0.0000 | 0.0002 | 0.0006 | 0.0001 | 0.0012 | 1.5594E-06 |
| 5.D.2 Industrial Wastewater | $CH_4$ | 137.025 | 138.525 | 64% | 30% | | | 0.0030 | | | | |
| 5.D.2 Industrial Wastewater | $N_2O$ | 2.341428614 | 0.115643072 | 23% | 30% | 0.3780 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.07046E-10 |
| Total | | 26256.4348 | 11353.3840 | | | | 0.0049 | | | | | 0.0003 |
| Total Uncertainties | | | | | | Uncertainty in total inventory %: | 7% | | | | Trend uncertainty %: | 2% |

# *Annex 3: Other Detailed methodological descriptions for individual source or sink categories, including for KP-LULUCF activities*

## A.3.1 Energy (excluding Transport sector)

| Fuel | NCV | Sulphur content (%) | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1990-95 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| **Diesel** | 42.49 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **RFO** | 40.6 | 2 | 2 | 2.12 | 2.10 | 2.00 | 2.08 | 1.98 | 1.96 | 2.02 | 1.38 | 1.23 | 0.99 | 1.21 | 0.91 | 0.79 | 0.91 | 0.97 | 0.94 | 0.80 | 0.84 |
| **Gasoline** | 43.97 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.005 | 0.005 | 0.005 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| **Jet fuel** | 43.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Other liquids** | 41.86 | 0.650 | 0.607 | 0.595 | 0.583 | 0.570 | 0.558 | 0.546 | 0.533 | 0.521 | 0.509 | 0.497 | 0.484 | 0.472 | 0.460 | 0.447 | 0.435 | 0.423 | 0.410 | 0.398 | 0.386 |
| **LPG** | 45.54 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 |
| **Shale oil** | 39.35 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| **Coal** | 26.22 | 1.8 | 1.8 | 1.47 | 1.37 | 1.06 | 0.90 | 0.87 | 0.78 | 0.66 | 0.67 | 0.72 | 0.66 | 0.52 | 0.45 | 0.46 | 0.39 | 0.41 | 0.50 | 0.44 | 0.48 |
| **Coke** | 26.79 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| **Oil shale** | 9.2 | 1.6 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat** | 10.05 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| **RFO (marine)** | 40.6 | 2 | 2 | 2 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1 | 1 | 1 | 1 | 1 |
| **Wood** | 6.7 | 0.0150 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 |
| **Natural gas** | Changes annually | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 | 0.00029 |
| | | **EF (kt/PJ)** | | | | | | | | | | | | | | | | | | | |
| **Diesel** | | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 |
| **RFO** | | 0.966 | 0.966 | 1.024 | 1.012 | 0.968 | 1.003 | 0.957 | 0.948 | 0.976 | 0.665 | 0.596 | 0.479 | 0.583 | 0.441 | 0.382 | 0.442 | 0.467 | 0.456 | 0.389 | 0.405 |
| **Gasoline** | | 0.00682 | 0.00682 | 0.00682 | 0.00682 | 0.00682 | 0.00682 | 0.00682 | 0.00682 | 0.00682 | 0.00682 | 0.00682 | 0.00227 | 0.00227 | 0.00227 | 0.00045 | 0.00045 | 0.00045 | 0.00045 | 0.00045 | 0.00045 |
| **Jet fuel** | | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 |
| **Other liquids** | | 0.311 | 0.290 | 0.284 | 0.278 | 0.272 | 0.267 | 0.261 | 0.255 | 0.249 | 0.243 | 0.237 | 0.231 | 0.225 | 0.220 | 0.214 | 0.208 | 0.202 | 0.196 | 0.190 | 0.184 |
| **LPG** | | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 | 0.00013 |
| **Shale oil** | | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 | 0.407 |
| **Coal** | | 1.138 | 1.138 | 0.928 | 0.865 | 0.673 | 0.567 | 0.551 | 0.493 | 0.451 | 0.459 | 0.498 | 0.454 | 0.357 | 0.308 | 0.318 | 0.266 | 0.280 | 0.342 | 0.328 | 0.359 |
| **Coke** | | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 |
| **Oil shale** | | 3.13 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat** | | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 | 0.507 |
| **RFO (marine)** | | 0.966 | 0.966 | 0.966 | 0.724 | 0.724 | 0.724 | 0.724 | 0.724 | 0.724 | 0.724 | 0.724 | 0.724 | 0.724 | 0.724 | 0.724 | 0.483 | 0.483 | 0.483 | 0.483 | 0.483 |
| **Wood** | | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 |
| **Natural gas** | | 0.00017 | 0.00018 | 0.00018 | 0.00018 | 0.00018 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00017 |

Notes:
Gasoline, diesel oil – EU legislation
RFO – EU legislation, average value from database Nr.2-Air
Other liquids – average value from database Nr.2-Air
Coal – average value from database Nr.2-Air

Shale oil – Luik, H. "Coal, oil shale, natural bitumen, heavy oil and peat" Vol. II *Chemicals and Other products from Shale Oil*
Oil shale – Gavrilova, O., Randla, T., Vallner, L., Strandberg, M., Vilu, R. 2005. "Life Cycle Analysis of the Estonian Oil Shale Industry"
Peat, peat briquettes – Latvian Peat Producers Association

Wood – Zandersons, J, Žūriņš, A., Rižikovs, J., Dobele, G., Latvian Institute of Wood chemistry "Feasibility of processing and utilisation of used up railway sleepers"
Natural gas – allowed content of mercaptan (3 mg/m$^3$)

## Fuel consumption in Energy sector (stationary combustion), TJ

### 1.A.1 Energy Industries

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.1. Energy Industries** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | **94337** | **88210** | **73651** | **57391** | **53160** | **50514** | **51326** | **52637** | **54187** | **48325** | **42657** | **44355** | **43268** | **43796** | **41000** | **40407** | **41916** | **39400** | **38929** | **37897** | **45595** | **42380** | **40380** | **46022** | **43785** |
| **Liquid Fuels** | 40437 | 33253 | 28441 | 27170 | 30859 | 20519 | 27333 | 17437 | 20662 | 17491 | 7900 | 5235 | 5033 | 3576 | 3055 | 2365 | 1511 | 1389 | 905 | 1194 | 918 | 848 | 662 | 466 | 319 |
| **Solid Fuels** | 2305 | 1736 | 1935 | 2106 | 1366 | 1395 | 740 | 541 | 455 | 398 | 371 | 398 | 285 | 209 | 210 | 183 | 105 | 341 | 446 | 472 | 419 | 419 | 513 | 424 | 175 |
| **Peat** | 2088 | 2343 | 2814 | 3007 | 2841 | 3430 | 2974 | 3083 | 2157 | 1275 | 2351 | 1230 | 1005 | 663 | 70 | 60 | 30 | 29 | 20 | 10 | 11 | 9 | NO | 40 | NO |
| **Gaseous Fuels** | 49029 | 50288 | 39788 | 24246 | 16770 | 24107 | 18644 | 28165 | 26802 | 25464 | 28803 | 33510 | 32497 | 34074 | 32371 | 33306 | 35181 | 32613 | 32650 | 31236 | 38687 | 35607 | 31872 | 33926 | 29870 |
| **Biomass** | 436 | 590 | 673 | 862 | 1324 | 1063 | 1634 | 3412 | 4111 | 3697 | 3232 | 3940 | 4406 | 5245 | 5206 | 4464 | 5089 | 5028 | 4908 | 4956 | 5531 | 5494 | 7333 | 11166 | 13421 |
| **Other Fossil Fuels** | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | 42 | 29 | 88 | 29 | NO | NO | NO | 29 | 29 | 3 | NO | NO | NO |
| **1.A.1.a. Public Electricity and Heat Production** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | **92472** | **86689** | **71901** | **55946** | **51496** | **48590** | **48499** | **51233** | **50453** | **44329** | **39919** | **42931** | **41998** | **42183** | **39348** | **39061** | **40483** | **38378** | **37639** | **36780** | **44274** | **40852** | **39004** | **44542** | **42275** |
| **Liquid Fuels** | 40098 | 33002 | 28190 | 26919 | 30426 | 20266 | 26110 | 17107 | 18116 | 14486 | 6350 | 5065 | 4821 | 3406 | 2843 | 2153 | 1299 | 1219 | 693 | 1031 | 705 | 593 | 492 | 211 | 33 |
| **Solid Fuels** | 2305 | 1736 | 1935 | 2106 | 1366 | 1395 | 740 | 541 | 427 | 370 | 371 | 398 | 285 | 209 | 210 | 183 | 105 | 341 | 446 | 472 | 419 | 419 | 513 | 424 | 175 |
| **Peat** | 1377 | 1703 | 1945 | 2437 | 2246 | 2703 | 2403 | 2600 | 1764 | 1046 | 1970 | 1125 | 995 | 653 | 60 | 40 | 20 | 20 | 20 | 10 | 11 | 9 | NO | 40 | NO |
| **Gaseous Fuels** | 48214 | 49658 | 39158 | 23622 | 16134 | 23163 | 17612 | 27599 | 26069 | 24831 | 27996 | 32633 | 31691 | 33199 | 31499 | 32434 | 34242 | 32043 | 31845 | 30739 | 37812 | 34664 | 30895 | 32997 | 29040 |
| **Biomass** | 436 | 590 | 673 | 862 | 1324 | 1063 | 1634 | 3386 | 4077 | 3596 | 3232 | 3668 | 4164 | 4687 | 4648 | 4222 | 4817 | 4755 | 4635 | 4499 | 5298 | 5164 | 7104 | 10870 | 13027 |
| **Other Fossil Fuels** | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | 42 | 29 | 88 | 29 | NO | NO | NO | 29 | 29 | 3 | NO | NO | NO |
| **Diesel oil** | 5524 | 5226 | 3824 | 935 | 382 | 85 | 42 | 297 | 85 | 85 | 127 | 42 | 42 | 42 | 42 | 42 | 42 | 43 | 43 | 16 | 15 | 25 | 127 | 94 | 22 |
| **RFO** | 32561 | 26147 | 23183 | 24563 | 30044 | 20016 | 25984 | 16768 | 17905 | 14007 | 5279 | 4425 | 4425 | 3207 | 2801 | 2111 | 1218 | 1137 | 650 | 1015 | 690 | 568 | 365 | 113 | 10 |
| **LPG** | 46 | 46 | 46 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 4 | 1 |
| **Other liquid** | 1967 | 1583 | 1137 | 1421 | NO | 126 | 84 | 42 | 126 | NO | NO | 126 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Shale oil** | NO | NO | NO | NO | NO | 39 | NO | NO | NO | 394 | 944 | 472 | 354 | 157 | NO | NO | 39 | 39 | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | 2305 | 1736 | 1935 | 2106 | 1366 | 1395 | 740 | 541 | 427 | 370 | 371 | 398 | 285 | 209 | 210 | 183 | 105 | 341 | 446 | 472 | 419 | 419 | 513 | 424 | 175 |
| **Peat briquettes** | 31 | 15 | 15 | 15 | 15 | 77 | 62 | 77 | 15 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 | NO | NO | NO | NO |
| **Peat** | 1346 | 1688 | 1930 | 2422 | 2231 | 2626 | 2341 | 2523 | 1749 | 1046 | 1970 | 1125 | 995 | 653 | 60 | 40 | 20 | 20 | 20 | 10 | 10 | 9 | NO | 40 | NO |
| **Natural gas** | 48214 | 49658 | 39158 | 23622 | 16134 | 23163 | 17612 | 27599 | 26069 | 24831 | 27996 | 32633 | 31691 | 33199 | 31499 | 32434 | 34242 | 32043 | 31845 | 30739 | 37812 | 34664 | 30895 | 32997 | 29040 |
| **Wood** | 436 | 590 | 673 | 831 | 1300 | 1045 | 1595 | 3363 | 4060 | 3558 | 3191 | 3617 | 4097 | 4644 | 4570 | 4132 | 4741 | 4675 | 4556 | 4390 | 5120 | 4635 | 5793 | 9198 | 11184 |
| **Sludge gas** | NO | NO | NO | 31 | 24 | 18 | 39 | 23 | 17 | 38 | 41 | 51 | 67 | 43 | 78 | 90 | 76 | 80 | 79 | 100 | 114 | 100 | 105 | 97 | 91 |
| **Landfill gas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 9 | 18 | 22 | 22 | 14 | 15 |
| **Other biogas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 37 | 355 | 1145 | 1561 | 1737 |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 8 | 52 | 39 | NO | NO |
| **Straws** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 | NO | NO | NO | NO |
| **Waste oils** | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | 42 | 29 | 88 | 29 | NO | NO | NO | 29 | 29 | 3 | NO | NO | NO |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | **1865** | **1521** | **1750** | **1445** | **1664** | **1924** | **2826** | **1405** | **3734** | **3996** | **2738** | **1424** | **1270** | **1613** | **1652** | **1346** | **1433** | **1022** | **1290** | **1117** | **1321** | **1528** | **1376** | **1480** | **1510** |
| **Liquid Fuels** | 339 | 251 | 251 | 251 | 433 | 253 | 1223 | 330 | 2546 | 3005 | 1550 | 170 | 212 | 170 | 212 | 212 | 212 | 170 | 212 | 163 | 213 | 255 | 170 | 255 | 286 |
| **Solid Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | 28 | 28 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat** | 711 | 640 | 869 | 570 | 595 | 727 | 571 | 483 | 393 | 229 | 381 | 105 | 10 | 10 | 10 | 20 | 10 | 9 | NO | NO | NO | NO | NO | NO | NO |
| **Gaseous Fuels** | 815 | 630 | 630 | 624 | 636 | 944 | 1032 | 566 | 733 | 633 | 807 | 877 | 806 | 875 | 872 | 872 | 939 | 570 | 805 | 497 | 875 | 943 | 977 | 929 | 830 |
| **Biomass** | NO | NO | NO | NO | NO | NO | NO | 26 | 34 | 101 | NO | 272 | 242 | 558 | 558 | 242 | 272 | 273 | 273 | 457 | 233 | 330 | 229 | 296 | 394 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Diesel oil** | 212 | 170 | 170 | 170 | 170 | 212 | 127 | 127 | 127 | 212 | 127 | 170 | 212 | 170 | 212 | 212 | 212 | 170 | 212 | 163 | 213 | 255 | 170 | 255 | 286 |
| **RFO** | 81 | 81 | 81 | 81 | 81 | 41 | 1096 | 203 | 487 | 731 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **LPG** | 46 | NO | NO | NO | 182 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Jet fuel** | NO | NO | NO | NO | NO | NO | NO | NO | 216 | 346 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | NO | NO | NO | NO | NO | NO | NO | NO | 1716 | 1716 | 1423 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | NO | NO | NO | NO | NO | NO | NO | NO | 28 | 28 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat** | 711 | 640 | 869 | 570 | 595 | 727 | 571 | 483 | 393 | 229 | 381 | 105 | 10 | 10 | 10 | 20 | 10 | 9 | NO | NO | NO | NO | NO | NO | NO |
| **Natural gas** | 815 | 630 | 630 | 624 | 636 | 944 | 1032 | 566 | 733 | 633 | 807 | 877 | 806 | 875 | 872 | 872 | 939 | 570 | 805 | 497 | 875 | 943 | 977 | 929 | 830 |
| **Wood** | NO | NO | NO | NO | NO | NO | NO | 26 | 34 | 101 | NO | 272 | 242 | 558 | 558 | 242 | 272 | 273 | 273 | 457 | 233 | 330 | 229 | 296 | 394 |

## 1.A.2 Manufacturing Industries and Construction

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.2 Manufacturing Industries and Construction** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 58640 | 45567 | 38083 | 32982 | 29888 | 29837 | 29430 | 28709 | 26228 | 24129 | 20526 | 20910 | 21411 | 21329 | 22992 | 24014 | 25616 | 24380 | 23176 | 22377 | 26693 | 25255 | 27930 | 26005 | 26913 |
| **Liquid Fuels** | 29747 | 20311 | 17430 | 17082 | 16545 | 16745 | 16344 | 16010 | 12910 | 11400 | 7575 | 4681 | 3966 | 4417 | 4277 | 2866 | 4075 | 3847 | 3076 | 2946 | 3500 | 2298 | 2649 | 2576 | 2254 |
| **Solid Fuels** | 1545 | 882 | 968 | 1639 | 1444 | 650 | 592 | 450 | 393 | 421 | 252 | 252 | 253 | 262 | 236 | 971 | 1394 | 1967 | 1997 | 1363 | 1861 | 2229 | 2149 | 1406 | 1336 |
| **Peat** | NO | 20 | 10 | NO | 15 | 15 | 15 | 25 | 25 | 15 | NO | NO | NO | NO | 10 | NO | NO | NO | NO | NO | 14 | 2 | 2 | 24 | 24 |
| **Gaseous Fuels** | 25894 | 23752 | 19059 | 12482 | 9783 | 10014 | 9815 | 9484 | 9712 | 9080 | 9873 | 11583 | 12838 | 12729 | 13157 | 13680 | 13395 | 12881 | 11836 | 9261 | 10537 | 7578 | 7952 | 6259 | 5258 |
| **Biomass** | 617 | 603 | 616 | 1779 | 2101 | 2414 | 2664 | 2740 | 3188 | 3186 | 2733 | 3926 | 3487 | 3391 | 4795 | 5584 | 6462 | 5415 | 5895 | 8674 | 10319 | 12399 | 14301 | 14624 | 16763 |
| **Other Fossil Fuels** | 837 | NO | NO | NO | NO | NO | NO | NO | NO | 26 | 94 | 469 | 866 | 530 | 517 | 914 | 290 | 270 | 372 | 133 | 462 | 749 | 877 | 1115 | 1279 |
| **Gasoline** | 880 | 220 | 220 | 220 | 132 | 44 | 132 | 88 | 88 | 44 | 44 | 44 | 69 | 44 | 88 | 88 | 88 | 88 | 88 | 44 | 44 | 44 | 44 | 44 | 43 |
| **Diesel oil** | 5564 | 5606 | 4034 | 3779 | 1611 | 1485 | 1315 | 1740 | 1655 | 1527 | 1484 | 1357 | 1231 | 1187 | 1357 | 1400 | 1527 | 1997 | 1657 | 1530 | 1359 | 1785 | 1997 | 1996 | 1722 |
| **RFO** | 22532 | 14007 | 12871 | 12504 | 14127 | 14413 | 14129 | 12993 | 9947 | 8446 | 3411 | 1625 | 1178 | 813 | 487 | 529 | 529 | 451 | 366 | 366 | 335 | 162 | 203 | 81 | 31 |
| **LPG** | 46 | 46 | 46 | 46 | 46 | 91 | 137 | 137 | 46 | 92 | 46 | 46 | 46 | 46 | 92 | 92 | 137 | 137 | 91 | 91 | 91 | 228 | 366 | 413 | 423 |
| **Jet fuel** | NO | NO | NO | NO | NO | NO | 43 | 86 | 43 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other kerosene** | 432 | 432 | 259 | 86 | 43 | 86 | 86 | 129 | 43 | 43 | 43 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | 293 | NO | NO | 447 | 586 | 586 | 502 | 837 | 1088 | 1130 | 1130 | 1215 | 1047 | 1214 | 1047 | 210 | 1089 | 963 | 795 | 711 | 1005 | NO | NO | 42 | 35 |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Petroleum coke** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 198 | 956 | 1088 | 429 | 627 | 132 | NO | 165 | 627 | NO | NO | NO | NO |
| **Shale oil** | NO | NO | NO | NO | NO | 39 | NO | NO | NO | 118 | 1417 | 394 | 197 | 157 | 118 | 118 | 78 | 79 | 79 | 39 | 39 | 79 | 39 | NO | NO |
| **Coal** | 1280 | 882 | 968 | 1534 | 1365 | 597 | 539 | 397 | 367 | 368 | 226 | 226 | 226 | 235 | 209 | 917 | 1362 | 1967 | 1997 | 1363 | 1861 | 2229 | 2067 | 1379 | 1336 |
| **Coke** | 237 | NO | NO | 105 | 79 | 53 | 53 | 53 | 26 | 53 | 26 | 26 | 27 | 27 | 27 | 54 | 32 | NO | NO | NO | NO | NO | NO | NO | NO |
| **Anthracite** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 82 | 27 | NO |
| **Oil shale** | 28 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat briquettes** | NO | NO | NO | NO | 15 | 15 | 15 | 15 | 15 | 15 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 4 | NO | NO | 4 | 4 |
| **Peat** | NO | 20 | 10 | NO | NO | NO | NO | 10 | 10 | NO | NO | NO | NO | NO | 10 | NO | NO | NO | NO | NO | 10 | 2 | 2 | 20 | 20 |
| **Natural gas** | 25894 | 23752 | 19059 | 12482 | 9783 | 10014 | 9815 | 9484 | 9712 | 9080 | 9873 | 11583 | 12838 | 12729 | 13157 | 13680 | 13395 | 12881 | 11836 | 9261 | 10537 | 7578 | 7952 | 6259 | 5258 |
| **Wood** | 617 | 603 | 616 | 1779 | 2101 | 2414 | 2664 | 2740 | 3188 | 3176 | 2696 | 3856 | 3393 | 3309 | 4706 | 5535 | 6425 | 5387 | 5797 | 8633 | 9801 | 11187 | 12921 | 13530 | 15368 |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 3 | 2 | 1 | 8 | 8 | 1 | 4 | 2 | 4 |
| **Other biogas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 18 | 125 | 57 | 125 |
| **Municipal wastes (biomass fraction)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | 10 | 37 | 70 | 94 | 82 | 89 | 49 | 34 | 26 | 98 | 33 | 510 | 1193 | 1250 | 1035 | 1266 |
| **Waste oils** | 837 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 293 | 628 | 322 | 293 | 789 | 205 | 205 | 234 | 88 | 58 | 85 | 58 | 29 | 29 |
| **Industrial wastes (used tires)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | 26 | 94 | 176 | 238 | 208 | 224 | 125 | 85 | 65 | 58 | 15 | 84 | 331 | 242 | 379 | 335 |
| **Municipal wastes** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 80 | 30 | 320 | 332 | 577 | 707 | 915 |
| **1.A.2.a. Iron and Steel** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 6331 | 4649 | 4157 | 3651 | 4019 | 3065 | 3282 | 5079 | 5083 | 4991 | 5076 | 5142 | 4861 | 4932 | 5016 | 4804 | 5059 | 5081 | 4738 | 4187 | 4870 | 1207 | 1633 | 583 | 13 |
| **Liquid Fuels** | 1219 | 1016 | 732 | 731 | 912 | 705 | 785 | 1162 | 1088 | 1130 | 1172 | 1042 | 963 | 963 | 963 | 126 | 963 | 963 | 917 | 792 | 1006 | NO | NO | NO | NO |
| **Solid Fuels** | NO | NO | NO | 28 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 27 | 27 | 5 | NO | NO | NO | 26 | 27 | 184 | 32 | NO |
| **Peat** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gaseous Fuels** | 4275 | 3633 | 3425 | 2892 | 3107 | 2360 | 2497 | 3917 | 3995 | 3861 | 3904 | 4058 | 3898 | 3969 | 4026 | 4125 | 4091 | 4118 | 3821 | 3395 | 3838 | 1180 | 1449 | 551 | 13 |
| **Biomass** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other Fossil Fuels** | 837 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | NO | NO | NO | 526 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Diesel oil** | 42 | 42 | 42 | NO | 42 | NO | NO | NO | NO | NO | 42 | NO | NO | NO | NO | 42 | NO | NO | NO | NO | 1 | NO | NO | NO | NO |
| **RFO** | 1177 | 974 | 690 | 284 | 284 | 203 | 325 | 325 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 122 | 81 | NO | NO | NO | NO | NO |
| **Other liquid** | NO | NO | NO | 447 | 586 | 502 | 460 | 837 | 1088 | 1130 | 1130 | 963 | 963 | 963 | 963 | 84 | 963 | 963 | 795 | 711 | 1005 | NO | NO | NO | NO |
| **Shale oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 79 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | NO | NO | NO | 28 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 26 | 27 | 102 | 5 | NO |
| **Coke** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 27 | 27 | 5 | NO | NO | NO | NO | NO | NO | NO | NO |
| **Anthracite** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 82 | 27 | NO |
| **Natural gas** | 4275 | 3633 | 3425 | 2892 | 3107 | 2360 | 2497 | 3917 | 3995 | 3861 | 3904 | 4058 | 3898 | 3969 | 4026 | 4125 | 4091 | 4118 | 3821 | 3395 | 3838 | 1180 | 1449 | 551 | 13 |
| **Waste oils** | 837 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | NO | NO | NO | 526 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| | | | | | | | | | | | | | | | | | | | | | | | | | |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.2.b. Non-Ferrous Metals** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | NO | NO | NO | NO | NO | NO | NO | NO | 53 | 100 | 168 | 232 | 269 | 302 | 269 | 203 | 204 | 201 | 134 | 101 | 135 | 172 | 173 | 138 | 72 |
| **Liquid Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO | 2 | 3 | NO | NO |
| **Solid Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 2 | 1 | NO | NO |
| **Peat** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gaseous Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | 53 | 100 | 168 | 190 | 269 | 302 | 269 | 203 | 204 | 201 | 134 | 101 | 135 | 168 | 168 | 138 | 72 |
| **Biomass** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 | NO | NO |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Diesel oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO | 2 | 3 | NO | NO |
| **Coal** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 2 | 1 | NO | NO |
| **Natural gas** | NO | NO | NO | NO | NO | NO | NO | NO | 53 | 100 | 168 | 190 | 269 | 302 | 269 | 203 | 204 | 201 | 134 | 101 | 135 | 168 | 168 | 138 | 72 |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 | NO | NO |
| **1.A.2.c. Chemicals** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 4070 | 2642 | 2098 | 3638 | 3977 | 5645 | 4160 | 3529 | 643 | 580 | 486 | 479 | 469 | 449 | 452 | 471 | 539 | 455 | 854 | 773 | 888 | 724 | 807 | 804 | 880 |
| **Liquid Fuels** | 3643 | 2059 | 1684 | 2963 | 3249 | 4547 | 3451 | 3207 | 325 | 164 | 122 | 164 | 162 | 122 | NO | NO | NO | NO | 124 | 126 | 94 | 131 | 154 | 137 | 159 |
| **Solid Fuels** | NO | NO | NO | 28 | 28 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 | NO | NO | NO |
| **Peat** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 20 | 11 |
| **Gaseous Fuels** | 427 | 584 | 414 | 643 | 693 | 1090 | 696 | 302 | 298 | 362 | 317 | 269 | 278 | 308 | 405 | 442 | 480 | 381 | 513 | 518 | 606 | 404 | 371 | 385 | 316 |
| **Biomass** | NO | NO | NO | 4 | 7 | 7 | 13 | 20 | 20 | 54 | 47 | 46 | 29 | 19 | 47 | 29 | 59 | 74 | 188 | 130 | 188 | 188 | 282 | 262 | 394 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 29 | NO | NO | NO | NO | NO | NO |
| **Diesel oil** | 127 | 127 | 85 | NO | 42 | NO | NO | NO | NO | 42 | NO | NO | NO | NO | NO | NO | NO | NO | 43 | 85 | 85 | 85 | 17 | NO | 15 |
| **RFO** | 3127 | 1543 | 1340 | 2963 | 3207 | 4547 | 3451 | 3207 | 325 | 122 | 122 | 122 | 162 | 122 | NO | NO | NO | NO | 81 | 41 | 9 | NO | NO | NO | NO |
| **LPG** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 46 | 137 | 137 | 144 |
| **Other kerosene** | 389 | 389 | 259 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | NO | NO | NO | 28 | 28 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 | NO | NO | NO |
| **Peat briquettes** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 |
| **Peat** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 20 | 10 |
| **Natural gas** | 427 | 584 | 414 | 643 | 693 | 1090 | 696 | 302 | 298 | 362 | 317 | 269 | 278 | 308 | 405 | 442 | 480 | 381 | 513 | 518 | 606 | 404 | 371 | 385 | 316 |
| **Wood** | NO | NO | NO | 4 | 7 | 7 | 13 | 20 | 20 | 54 | 47 | 46 | 29 | 19 | 47 | 29 | 56 | 72 | 187 | 127 | 187 | 169 | 210 | 208 | 278 |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 3 | 2 | 1 | 3 | 1 | 1 | NO | NO | 1 |
| **Other biogas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 18 | 72 | 54 | 115 |
| **Waste oils** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 29 | NO | NO | NO | NO | NO | NO |
| **1.A.2.d. Pulp, Paper and Print** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 2956 | 2827 | 2562 | 953 | 330 | 326 | 194 | 181 | 142 | 168 | 124 | 176 | 182 | 214 | 213 | 255 | 281 | 217 | 208 | 264 | 260 | 223 | 176 | 200 | 106 |
| **Liquid Fuels** | 203 | 162 | 122 | 122 | 41 | 81 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 3 | 14 | 6 | NO | 6 |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Solid Fuels** | 28 | 28 | 28 | 113 | 56 | 56 | 56 | 57 | 28 | 28 | NO | 28 | 28 | 26 | 26 | 26 | 26 | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gaseous Fuels** | 2724 | 2637 | 2412 | 653 | 45 | 101 | 118 | 104 | 94 | 100 | 101 | 135 | 134 | 168 | 167 | 202 | 235 | 201 | 201 | 101 | 101 | 101 | 68 | 103 | 97 |
| **Biomass** | NO | NO | NO | 65 | 188 | 87 | 20 | 20 | 20 | 40 | 23 | 13 | 20 | 20 | 20 | 27 | 20 | 16 | 7 | 163 | 156 | 108 | 102 | 97 | 3 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Diesel oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 3 | 14 | 6 | NO | 2 |
| **RFO** | 203 | 162 | 122 | 122 | 41 | 81 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **LPG** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 4 |
| **Coal** | 28 | 28 | 28 | 113 | 56 | 56 | 56 | 57 | 28 | 28 | NO | 28 | 28 | 26 | 26 | 26 | 26 | NO | NO | NO | NO | NO | NO | NO | NO |
| **Natural gas** | 2724 | 2637 | 2412 | 653 | 45 | 101 | 118 | 104 | 94 | 100 | 101 | 135 | 134 | 168 | 167 | 202 | 235 | 201 | 201 | 101 | 101 | 101 | 68 | 103 | 97 |
| **Wood** | NO | NO | NO | 65 | 188 | 87 | 20 | 20 | 20 | 40 | 23 | 13 | 20 | 20 | 20 | 27 | 20 | 16 | 7 | 163 | 156 | 108 | 102 | 97 | 3 |
| **1.A.2.e. Food Processing, Beverages and Tobacco** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 15020 | 11250 | 10442 | 11139 | 8145 | 8394 | 9317 | 8809 | 8443 | 7299 | 6167 | 5366 | 5452 | 4763 | 5219 | 5315 | 5131 | 4254 | 3351 | 3086 | 2908 | 2694 | 2911 | 2789 | 2637 |
| **Liquid Fuels** | 10547 | 7700 | 7046 | 6807 | 4419 | 4693 | 5429 | 5205 | 5238 | 4133 | 2970 | 1651 | 1442 | 1034 | 873 | 912 | 916 | 673 | 420 | 586 | 566 | 376 | 500 | 475 | 378 |
| **Solid Fuels** | 1069 | 598 | 655 | 594 | 565 | 309 | 309 | 252 | 168 | 224 | 140 | 140 | 141 | 158 | 105 | 132 | 106 | 79 | 79 | 52 | 52 | 16 | 27 | 25 | 24 |
| **Peat** | NO | NO | NO | NO | 15 | NO | NO | 15 | 15 | 15 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 3 | NO | NO | NO | NO |
| **Gaseous Fuels** | 3177 | 2722 | 2511 | 3500 | 2829 | 3065 | 3250 | 3013 | 2694 | 2578 | 2607 | 2775 | 2985 | 2764 | 3238 | 3149 | 3249 | 2684 | 2370 | 1930 | 1919 | 1886 | 1819 | 1808 | 1729 |
| **Biomass** | 228 | 231 | 230 | 238 | 316 | 327 | 330 | 325 | 328 | 349 | 450 | 800 | 842 | 719 | 916 | 1034 | 772 | 701 | 394 | 488 | 339 | 360 | 536 | 452 | 477 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | 88 | 88 | 88 | 88 | 117 | 88 | 30 | 29 | 56 | 29 | 29 | 29 |
| **Diesel oil** | 3229 | 3229 | 3102 | 3229 | 765 | 552 | 510 | 807 | 722 | 552 | 552 | 467 | 340 | 340 | 340 | 297 | 255 | 213 | 212 | 212 | 170 | 85 | 121 | 170 | 152 |
| **RFO** | 7105 | 4425 | 3898 | 3532 | 3654 | 4060 | 4791 | 4223 | 4384 | 3492 | 1745 | 975 | 893 | 609 | 406 | 406 | 447 | 329 | 122 | 244 | 285 | 121 | 203 | 81 | 31 |
| **LPG** | 46 | 46 | 46 | 46 | NO | NO | NO | 46 | 46 | 46 | NO | 46 | 46 | 46 | 46 | 46 | 91 | 91 | 46 | 91 | 72 | 91 | 137 | 182 | 160 |
| **Jet fuel** | NO | NO | NO | NO | NO | NO | 43 | 86 | 43 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other kerosene** | NO | NO | NO | NO | NO | NO | 43 | 43 | 43 | 43 | 43 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | 167 | NO | NO | NO | NO | 42 | 42 | NO | NO | NO | NO | 84 | 84 | NO | 42 | 84 | 84 | NO | NO | NO | NO | NO | NO | 42 | 35 |
| **Shale oil** | NO | NO | NO | NO | NO | 39 | NO | NO | NO | NO | 630 | 79 | 79 | 39 | 39 | 79 | 39 | 40 | 40 | 39 | 39 | 79 | 39 | NO | NO |
| **Coal** | 911 | 598 | 655 | 541 | 512 | 256 | 256 | 199 | 142 | 171 | 114 | 114 | 114 | 131 | 105 | 105 | 79 | 79 | 79 | 52 | 52 | 16 | 27 | 25 | 24 |
| **Coke** | 158 | NO | NO | 53 | 53 | 53 | 53 | 53 | 26 | 53 | 26 | 26 | 27 | 27 | NO | 27 | 27 | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat briquettes** | NO | NO | NO | NO | 15 | NO | NO | 15 | 15 | 15 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 3 | NO | NO | NO | NO |
| **Natural gas** | 3177 | 2722 | 2511 | 3500 | 2829 | 3065 | 3250 | 3013 | 2694 | 2578 | 2607 | 2775 | 2985 | 2764 | 3238 | 3149 | 3249 | 2684 | 2370 | 1930 | 1919 | 1886 | 1819 | 1808 | 1729 |
| **Wood** | 228 | 231 | 230 | 238 | 316 | 327 | 330 | 325 | 328 | 349 | 450 | 800 | 842 | 719 | 916 | 1034 | 772 | 701 | 394 | 483 | 333 | 360 | 535 | 449 | 467 |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 5 | 6 | NO | 1 | 0 | NO |
| **Other biogas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 3 | 10 |
| **Waste oils** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | 88 | 88 | 88 | 88 | 117 | 88 | 30 | 29 | 56 | 29 | 29 | 29 |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.2.f. Non-metallic minerals** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 9496 | 5911 | 5584 | 2962 | 3998 | 4052 | 3941 | 3145 | 3045 | 3071 | 2512 | 2797 | 3673 | 3903 | 3648 | 4271 | 4296 | 4484 | 4307 | 2694 | 4555 | 5271 | 5573 | 5062 | 5400 |
| **Liquid Fuels** | 3585 | 1307 | 1301 | 1260 | 3057 | 2562 | 2519 | 2396 | 1912 | 2274 | 1521 | 482 | 358 | 1367 | 1209 | 764 | 920 | 379 | 207 | 293 | 864 | 298 | 291 | 297 | 275 |
| **Solid Fuels** | 170 | 85 | 114 | 199 | 171 | 114 | 57 | 85 | 28 | 28 | 28 | 28 | 28 | 26 | 26 | 682 | 1127 | 1809 | 1888 | 1285 | 1757 | 2136 | 1910 | 1299 | 1254 |
| **Peat** | NO | NO | NO | NO | NO | NO | NO | 10 | 10 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gaseous Fuels** | 5734 | 4513 | 4163 | 1476 | 750 | 1282 | 1345 | 634 | 1066 | 698 | 808 | 1821 | 2352 | 1884 | 1845 | 2381 | 1878 | 1979 | 1782 | 942 | 1010 | 977 | 1280 | 1344 | 1353 |
| **Biomass** | 7 | 6 | 6 | 27 | 20 | 94 | 20 | 20 | 29 | 44 | 61 | 82 | 111 | 184 | 139 | 144 | 169 | 165 | 175 | 100 | 520 | 1196 | 1273 | 1035 | 1269 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | 26 | 94 | 385 | 824 | 442 | 429 | 300 | 202 | 153 | 255 | 74 | 404 | 664 | 819 | 1086 | 1250 |
| **Diesel oil** | 127 | 127 | 42 | 42 | 169 | 84 | 42 | 42 | 85 | 85 | 42 | 42 | 42 | 42 | 42 | 255 | 212 | 127 | 127 | 128 | 237 | 298 | 291 | 297 | 275 |
| **RFO** | 3289 | 1137 | 1259 | 1218 | 2842 | 2436 | 2477 | 2354 | 1827 | 2071 | 731 | 162 | NO | NO | NO | 41 | NO | 81 | 41 | NO | NO | NO | NO | NO | NO |
| **LPG** | NO | NO | NO | NO | 46 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other kerosene** | 43 | 43 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | 126 | NO | NO | NO | NO | 42 | NO | NO | NO | NO | NO | 42 | NO | 251 | NO | NO | 42 | NO | NO | NO | NO | NO | NO | NO | NO |
| **Petroleum coke** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 198 | 956 | 1088 | 429 | 627 | 132 | NO | 165 | 627 | NO | NO | NO | NO |
| **Shale oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | 118 | 748 | 236 | 118 | 118 | 79 | 39 | 39 | 39 | 39 | NO | NO | NO | NO | NO | NO |
| **Coal** | 142 | 85 | 114 | 199 | 171 | 114 | 57 | 85 | 28 | 28 | 28 | 28 | 28 | 26 | 26 | 682 | 1127 | 1809 | 1888 | 1285 | 1757 | 2136 | 1910 | 1299 | 1254 |
| **Oil shale** | 28 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat** | NO | NO | NO | NO | NO | NO | NO | 10 | 10 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Natural gas** | 5734 | 4513 | 4163 | 1476 | 750 | 1282 | 1345 | 634 | 1066 | 698 | 808 | 1821 | 2352 | 1884 | 1845 | 2381 | 1878 | 1979 | 1782 | 942 | 1010 | 977 | 1280 | 1344 | 1353 |
| **Wood** | 7 | 6 | 6 | 27 | 20 | 94 | 20 | 20 | 29 | 34 | 24 | 12 | 17 | 102 | 50 | 95 | 135 | 139 | 77 | 67 | 10 | 3 | 23 | NO | NO |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 3 |
| **Municipal wastes (biomass fraction)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | 10 | 37 | 70 | 94 | 82 | 89 | 49 | 34 | 26 | 98 | 33 | 510 | 1193 | 1250 | 1035 | 1266 |
| **Waste oils** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 209 | 586 | 234 | 205 | 175 | 117 | 88 | 117 | 29 | NO | NO | NO | NO | NO |
| **Industrial wastes (used tires)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | 26 | 94 | 176 | 238 | 208 | 224 | 125 | 85 | 65 | 58 | 15 | 84 | 331 | 242 | 379 | 335 |
| **Municipal wastes** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 80 | 30 | 320 | 332 | 577 | 707 | 915 |
| **1.A.2.g. Other** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 20768 | 18288 | 13240 | 10639 | 9420 | 8356 | 8536 | 7965 | 8819 | 7920 | 5993 | 6718 | 6504 | 6766 | 8175 | 8695 | 10106 | 9688 | 9583 | 11272 | 13077 | 14964 | 16657 | 16429 | 17805 |
| **Liquid Fuels** | 10551 | 8067 | 6546 | 5199 | 4867 | 4156 | 4160 | 4039 | 4347 | 3699 | 1790 | 1300 | 1041 | 931 | 1233 | 1064 | 1276 | 1832 | 1408 | 1149 | 967 | 1477 | 1695 | 1667 | 1436 |
| **Solid Fuels** | 278 | 171 | 171 | 677 | 623 | 170 | 169 | 56 | 169 | 141 | 84 | 56 | 56 | 52 | 52 | 104 | 130 | 79 | 30 | 26 | 26 | 47 | 27 | 50 | 58 |
| **Peat** | NO | 20 | 10 | NO | NO | 15 | 15 | NO | NO | NO | NO | NO | NO | NO | 10 | NO | NO | NO | NO | NO | 11 | 2 | 2 | 4 | 13 |
| **Gaseous Fuels** | 9557 | 9664 | 6134 | 3318 | 2360 | 2115 | 1910 | 1515 | 1512 | 1380 | 1968 | 2335 | 2922 | 3334 | 3208 | 3177 | 3258 | 3318 | 3014 | 2275 | 2928 | 2862 | 2797 | 1930 | 1678 |
| **Biomass** | 382 | 366 | 380 | 1445 | 1570 | 1899 | 2281 | 2355 | 2791 | 2699 | 2152 | 2985 | 2485 | 2449 | 3673 | 4350 | 5442 | 4459 | 5132 | 7793 | 9116 | 10547 | 12107 | 12778 | 14620 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | NO | NO | NO | NO | NO | NO | NO | 29 | 29 | 29 | 29 | NO | NO |
| **Gasoline** | 880 | 220 | 220 | 220 | 132 | 44 | 132 | 88 | 88 | 44 | 44 | 44 | 69 | 44 | 88 | 88 | 88 | 88 | 88 | 44 | 44 | 44 | 44 | 44 | 43 |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Diesel oil** | 2039 | 2081 | 763 | 508 | 593 | 849 | 763 | 891 | 848 | 848 | 848 | 806 | 849 | 805 | 975 | 806 | 1060 | 1657 | 1275 | 1105 | 863 | 1301 | 1559 | 1529 | 1278 |
| **RFO** | 7632 | 5766 | 5563 | 4385 | 4099 | 3086 | 3085 | 2883 | 3411 | 2761 | 813 | 366 | 123 | 82 | 82 | 82 | 82 | 41 | NO | NO | 41 | 41 | NO | NO | NO |
| **LPG** | NO | NO | NO | NO | NO | 91 | 137 | 91 | NO | 46 | 46 | NO | NO | NO | 46 | 46 | 46 | 46 | 45 | NO | 19 | 91 | 92 | 94 | 115 |
| **Other kerosene** | NO | NO | NO | 86 | 43 | 86 | 43 | 86 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 84 | NO | NO | 42 | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Shale oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 39 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | 199 | 171 | 171 | 625 | 597 | 170 | 169 | 56 | 169 | 141 | 84 | 56 | 56 | 52 | 52 | 104 | 130 | 79 | 30 | 26 | 26 | 47 | 27 | 50 | 58 |
| **Coke** | 79 | NO | NO | 52 | 26 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat briquettes** | NO | NO | NO | NO | NO | 15 | 15 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 | NO | NO | 4 | 3 |
| **Peat** | NO | 20 | 10 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 10 | NO | NO | NO | NO | NO | 10 | 2 | 2 | NO | 10 |
| **Natural gas** | 9557 | 9664 | 6134 | 3318 | 2360 | 2115 | 1910 | 1515 | 1512 | 1380 | 1968 | 2335 | 2922 | 3334 | 3208 | 3177 | 3258 | 3318 | 3014 | 2275 | 2928 | 2862 | 2797 | 1930 | 1678 |
| **Wood** | 382 | 366 | 380 | 1445 | 1570 | 1899 | 2281 | 2355 | 2791 | 2699 | 2152 | 2985 | 2485 | 2449 | 3673 | 4350 | 5442 | 4459 | 5132 | 7793 | 9115 | 10547 | 12051 | 12776 | 14620 |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 | NO | 2 | 2 | NO |
| **Other biogas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 54 | NO | NO |
| **Waste oils** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | NO | NO | NO | NO | NO | NO | NO | 29 | 29 | 29 | 29 | NO | NO |

## 1.A.4 Other Sectors

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.4 Other Sectors** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 102092 | 108961 | 83730 | 77831 | 64625 | 60182 | 61263 | 56261 | 52470 | 52089 | 49117 | 54029 | 53828 | 57273 | 59428 | 59055 | 58857 | 59344 | 55403 | 58823 | 52940 | 51629 | 53940 | 50148 | 49247 |
| **Liquid Fuels** | 27829 | 32499 | 24223 | 21319 | 14008 | 8817 | 8761 | 7849 | 6947 | 7439 | 6888 | 7363 | 6919 | 7887 | 7936 | 7807 | 8456 | 7888 | 7114 | 7778 | 8334 | 8351 | 8351 | 8476 | 8753 |
| **Solid Fuels** | 22398 | 19894 | 15853 | 13347 | 9363 | 5180 | 5521 | 4639 | 3330 | 2817 | 2162 | 2988 | 2390 | 2203 | 2150 | 2045 | 1940 | 1940 | 1783 | 1574 | 2098 | 1861 | 983 | 1075 | 962 |
| **Peat** | 1128 | 880 | 1030 | 617 | 515 | 391 | 506 | 357 | 266 | 66 | 41 | 15 | NO | 10 | NO | 20 | 40 | 61 | 31 | 16 | 21 | 32 | 32 | NO | 11 |
| **Gaseous Fuels** | 24289 | 24628 | 11751 | 9338 | 7002 | 7150 | 6732 | 5434 | 5670 | 5865 | 6218 | 7061 | 8098 | 8795 | 9651 | 9632 | 9983 | 11027 | 10959 | 10241 | 11819 | 10343 | 10477 | 9809 | 9670 |
| **Biomass** | 26448 | 31060 | 30873 | 33210 | 33737 | 38643 | 39743 | 37983 | 36257 | 35902 | 33808 | 36561 | 36295 | 38321 | 39574 | 39523 | 38380 | 38399 | 35487 | 39215 | 30659 | 31042 | 34097 | 30788 | 29851 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | 126 | 58 | 117 | 29 | 58 | 29 | 29 | NO | 8 | NO | NO | NO | NO |
| **Gasoline** | 1672 | 176 | 176 | 176 | 352 | 88 | 176 | 176 | 88 | 132 | 264 | 220 | 195 | 220 | 220 | 308 | 352 | 352 | 308 | 308 | 308 | 440 | 395 | 440 | 354 |
| **Diesel oil** | 16189 | 22860 | 16189 | 14574 | 6840 | 5267 | 5098 | 4248 | 3611 | 4419 | 4589 | 5099 | 4886 | 5651 | 5863 | 5566 | 6288 | 6288 | 5566 | 6365 | 6942 | 6902 | 6896 | 6981 | 7234 |
| **RFO** | 6415 | 6292 | 5318 | 3897 | 4507 | 1664 | 1990 | 1706 | 1340 | 1218 | 772 | 772 | 569 | 528 | 447 | 527 | 406 | 40 | 80 | 41 | 44 | 5 | NO | NO | NO |
| **LPG** | 2961 | 2869 | 2368 | 2413 | 2050 | 1366 | 1367 | 1503 | 1822 | 1412 | 1184 | 1230 | 1185 | 1321 | 1321 | 1367 | 1367 | 1184 | 1139 | 1047 | 1023 | 1002 | 1055 | 1055 | 1165 |
| **Jet fuel** | NO | NO | NO | NO | NO | 86 | 43 | 173 | 43 | 130 | NO | NO | NO | NO | 43 | NO | 43 | 24 | 21 | 17 | 17 | 2 | 4 | NO | NO |
| **Other kerosene** | 215 | 302 | 172 | 259 | 259 | 346 | 86 | 43 | 43 | 86 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | 377 | NO | NO | NO | NO | NO | NO | NO | NO | 42 | NO | 42 | 84 | 167 | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Shale oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 79 | NO | NO | NO | NO | 39 | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Coal** | 22398 | 19894 | 15853 | 13347 | 9363 | 5180 | 5521 | 4639 | 3330 | 2817 | 2162 | 2988 | 2390 | 2203 | 2150 | 2045 | 1940 | 1940 | 1783 | 1574 | 2098 | 1861 | 983 | 1075 | 962 |
| **Peat briquettes** | 836 | 588 | 728 | 527 | 294 | 309 | 355 | 247 | 186 | 46 | 31 | 15 | NO | NO | NO | NO | NO | 1 | 1 | 6 | 1 | 3 | 4 | NO | 1 |
| **Peat** | 292 | 292 | 302 | 90 | 221 | 82 | 150 | 110 | 80 | 20 | 10 | NO | NO | 10 | NO | 20 | 40 | 60 | 30 | 10 | 20 | 29 | 28 | NO | 10 |
| **Natural gas** | 24289 | 24628 | 11751 | 9338 | 7002 | 7150 | 6732 | 5434 | 5670 | 5865 | 6218 | 7061 | 8098 | 8795 | 9651 | 9632 | 9983 | 11027 | 10959 | 10241 | 11819 | 10343 | 10477 | 9809 | 9670 |
| **Wood** | 26448 | 31060 | 30873 | 33210 | 33737 | 38643 | 39743 | 37983 | 36257 | 35902 | 33808 | 36561 | 36249 | 38159 | 39302 | 39211 | 38080 | 38067 | 35123 | 38811 | 30222 | 30442 | 33226 | 29652 | 28585 |
| **Charcoal** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 30 | 60 | 30 | 45 | 60 | 60 | 60 | 60 | 59 | 90 | 90 |
| **Landfill gas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 46 | 162 | 242 | 251 | 259 | 271 | 290 | 314 | 314 | 327 | 326 | 357 | 333 |
| **Other biogas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 91 | 358 | 523 | 673 |
| **Straws** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 11 | 16 | 14 | 29 | 59 | 43 | 38 | 58 | 99 |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 5 | 79 | 90 | 108 | 71 |
| **Waste oils** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | 126 | 58 | 117 | 29 | 58 | 29 | 29 | NO | 8 | NO | NO | NO | NO |
| **1.A.4.a. Commercial/Institutional** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 40346 | 40142 | 34150 | 27786 | 17464 | 16517 | 16581 | 14795 | 12297 | 13125 | 11356 | 12366 | 13179 | 13856 | 15142 | 14292 | 14964 | 15997 | 13248 | 12578 | 13329 | 11772 | 12744 | 12526 | 12018 |
| **Liquid Fuels** | 13453 | 16642 | 11910 | 10556 | 5308 | 2890 | 2758 | 2459 | 2017 | 2346 | 1715 | 1928 | 1818 | 2207 | 2167 | 1860 | 2289 | 1902 | 1596 | 1586 | 1619 | 1397 | 1859 | 1939 | 2129 |
| **Solid Fuels** | 14913 | 11413 | 10872 | 7854 | 4297 | 2903 | 3272 | 2732 | 2419 | 2049 | 1565 | 1536 | 1423 | 1338 | 1285 | 1049 | 1075 | 1075 | 918 | 735 | 1023 | 891 | 354 | 519 | 407 |
| **Peat** | 672 | 517 | 620 | 288 | 326 | 114 | 250 | 163 | 71 | 15 | 31 | 15 | NO | 10 | NO | 20 | 40 | 61 | 31 | 16 | 1 | 32 | 32 | NO | 11 |
| **Gaseous Fuels** | 6090 | 6408 | 5466 | 3579 | 1903 | 2328 | 2271 | 1805 | 2175 | 2536 | 3054 | 3347 | 4103 | 4278 | 4680 | 4598 | 4851 | 5676 | 5679 | 5415 | 5623 | 5055 | 4952 | 4477 | 4401 |
| **Biomass** | 5218 | 5162 | 5282 | 5508 | 5630 | 8282 | 8029 | 7636 | 5615 | 6179 | 4991 | 5497 | 5709 | 5965 | 6894 | 6737 | 6651 | 7253 | 4995 | 4826 | 5054 | 4398 | 5547 | 5591 | 5070 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | 126 | 58 | 117 | 29 | 58 | 29 | 29 | NO | 8 | NO | NO | NO | NO |
| **Gasoline** | 44 | 44 | 44 | 44 | 220 | NO | 88 | 88 | 44 | 88 | 88 | 77 | 46 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 88 | 44 | 88 | 44 |
| **Diesel oil** | 8116 | 11515 | 7436 | 7478 | 1529 | 1189 | 1147 | 552 | 340 | 935 | 1020 | 1190 | 1317 | 1530 | 1657 | 1275 | 1700 | 1657 | 1360 | 1393 | 1418 | 1251 | 1713 | 1755 | 1924 |
| **RFO** | 4953 | 4953 | 4344 | 2679 | 3248 | 1177 | 1300 | 1421 | 1137 | 974 | 528 | 528 | 325 | 284 | 244 | 365 | 365 | 40 | 80 | 41 | 41 | 2 | NO | NO | NO |
| **LPG** | 46 | NO | NO | 182 | 137 | 91 | 137 | 182 | 410 | 91 | NO | 91 | 46 | 182 | 137 | 137 | 137 | 137 | 91 | 91 | 99 | 54 | 98 | 96 | 161 |
| **Jet fuel** | NO | NO | NO | NO | NO | 86 | 43 | 173 | 43 | 130 | NO | NO | NO | NO | 43 | NO | 43 | 24 | 21 | 17 | 17 | 2 | 4 | NO | NO |
| **Other kerosene** | 43 | 130 | 86 | 173 | 173 | 346 | 43 | 43 | 43 | 86 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | 251 | NO | NO | NO | NO | NO | NO | NO | NO | 42 | NO | 42 | 84 | 167 | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Shale oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 79 | NO | NO | NO | NO | 39 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | 14913 | 11413 | 10872 | 7854 | 4297 | 2903 | 3272 | 2732 | 2419 | 2049 | 1565 | 1536 | 1423 | 1338 | 1285 | 1049 | 1075 | 1075 | 918 | 735 | 1023 | 891 | 354 | 519 | 407 |
| **Peat briquettes** | 511 | 356 | 449 | 248 | 155 | 62 | 139 | 93 | 31 | 15 | 31 | 15 | NO | NO | NO | NO | NO | 1 | 1 | 6 | 1 | 3 | 4 | NO | 1 |
| **Peat** | 161 | 161 | 171 | 40 | 171 | 52 | 110 | 70 | 40 | NO | NO | NO | NO | 10 | NO | 20 | 40 | 60 | 30 | 10 | NO | 29 | 28 | NO | 10 |
| **Natural gas** | 6090 | 6408 | 5466 | 3579 | 1903 | 2328 | 2271 | 1805 | 2175 | 2536 | 3054 | 3347 | 4103 | 4278 | 4680 | 4598 | 4851 | 5676 | 5679 | 5415 | 5623 | 5055 | 4952 | 4477 | 4401 |
| **Wood** | 5218 | 5162 | 5282 | 5508 | 5630 | 8282 | 8029 | 7636 | 5615 | 6179 | 4991 | 5497 | 5663 | 5803 | 6652 | 6485 | 6381 | 6966 | 4691 | 4482 | 4680 | 3997 | 5163 | 5087 | 4603 |
| **Landfill gas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 46 | 162 | 242 | 251 | 259 | 271 | 290 | 314 | 314 | 327 | 326 | 357 | 333 |
| **Other biogas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 49 | 69 |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Straws** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 11 | 16 | 14 | 29 | 57 | 43 | 24 | 44 | 53 |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 4 | 31 | 34 | 54 | 12 |
| **Waste oils** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 42 | 126 | 58 | 117 | 29 | 58 | 29 | 29 | NO | 8 | NO | NO | NO | NO |
| **1.A.4.b. Residential** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 35751 | 42489 | 39047 | 40790 | 38562 | 37659 | 38588 | 36043 | 35336 | 34027 | 32851 | 36298 | 35666 | 37702 | 38261 | 38948 | 37955 | 37271 | 37067 | 40809 | 33561 | 33797 | 35117 | 31228 | 30846 |
| **Liquid Fuels** | 4908 | 5671 | 5003 | 4010 | 2848 | 1402 | 1272 | 1363 | 1454 | 1406 | 1443 | 1441 | 1441 | 1398 | 1443 | 1577 | 1621 | 1438 | 1393 | 2025 | 2237 | 2229 | 2236 | 2237 | 2283 |
| **Solid Fuels** | 6404 | 7542 | 4440 | 5037 | 4411 | 1821 | 1964 | 1708 | 797 | 683 | 512 | 1338 | 854 | 787 | 787 | 944 | 813 | 813 | 813 | 813 | 1049 | 944 | 577 | 530 | 531 |
| **Peat** | 425 | 332 | 379 | 258 | 144 | 252 | 241 | 179 | 195 | 51 | 10 | NO | NO | NO | NO | NO | NO | NO | NO | NO | 20 | NO | NO | NO | NO |
| **Gaseous Fuels** | 4004 | 4275 | 4905 | 5089 | 4359 | 4181 | 3762 | 3063 | 2896 | 2829 | 2659 | 3001 | 3293 | 3667 | 3958 | 4193 | 4326 | 4587 | 4693 | 4304 | 5219 | 4480 | 4481 | 4266 | 4252 |
| **Biomass** | 20010 | 24669 | 24320 | 26396 | 26800 | 30003 | 31349 | 29730 | 29994 | 29058 | 28227 | 30518 | 30078 | 31850 | 32073 | 32234 | 31195 | 30433 | 30168 | 33667 | 25036 | 26144 | 27823 | 24195 | 23780 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gasoline** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 132 | 132 | 132 | 132 | 132 | 220 | 264 | 264 | 264 | 264 | 264 | 264 | 263 | 264 | 264 |
| **Diesel oil** | 1912 | 2762 | 2592 | 1827 | 892 | 127 | 42 | 42 | 42 | 85 | 127 | 170 | 170 | 127 | 127 | 127 | 127 | 127 | 127 | 850 | 1062 | 1062 | 1062 | 1062 | 1062 |
| **RFO** | 41 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **LPG** | 2869 | 2823 | 2368 | 2140 | 1913 | 1275 | 1230 | 1321 | 1412 | 1321 | 1184 | 1139 | 1139 | 1139 | 1184 | 1230 | 1230 | 1047 | 1002 | 911 | 911 | 903 | 911 | 911 | 957 |
| **Other kerosene** | 86 | 86 | 43 | 43 | 43 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | 6404 | 7542 | 4440 | 5037 | 4411 | 1821 | 1964 | 1708 | 797 | 683 | 512 | 1338 | 854 | 787 | 787 | 944 | 813 | 813 | 813 | 813 | 1049 | 944 | 577 | 530 | 531 |
| **Peat briquettes** | 294 | 201 | 248 | 248 | 124 | 232 | 201 | 139 | 155 | 31 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat** | 131 | 131 | 131 | 10 | 20 | 20 | 40 | 40 | 40 | 20 | 10 | NO | NO | NO | NO | NO | NO | NO | NO | NO | 20 | NO | NO | NO | NO |
| **Natural gas** | 4004 | 4275 | 4905 | 5089 | 4359 | 4181 | 3762 | 3063 | 2896 | 2829 | 2659 | 3001 | 3293 | 3667 | 3958 | 4193 | 4326 | 4587 | 4693 | 4304 | 5219 | 4480 | 4481 | 4266 | 4252 |
| **Wood** | 20010 | 24669 | 24320 | 26396 | 26800 | 30003 | 31349 | 29730 | 29994 | 29058 | 28227 | 30518 | 30078 | 31850 | 32043 | 32174 | 31165 | 30388 | 30108 | 33607 | 24974 | 26084 | 27764 | 24105 | 23690 |
| **Charcoal** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 30 | 60 | 30 | 45 | 60 | 60 | 60 | 60 | 59 | 90 | 90 |
| **Straws** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 2 | NO | NO | NO | NO |
| **1.A.4.c. Agriculture/Forestry/Fisheries** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | 25995 | 26331 | 10533 | 9255 | 8599 | 6005 | 6094 | 5424 | 4837 | 4937 | 4910 | 5365 | 4983 | 5716 | 6025 | 5815 | 5938 | 6077 | 5088 | 5436 | 6050 | 6059 | 6079 | 6394 | 6383 |
| **Liquid Fuels** | 9468 | 10186 | 7310 | 6752 | 5852 | 4526 | 4731 | 4027 | 3476 | 3687 | 3730 | 3994 | 3660 | 4282 | 4326 | 4370 | 4546 | 4548 | 4125 | 4167 | 4478 | 4725 | 4255 | 4300 | 4341 |
| **Solid Fuels** | 1081 | 939 | 541 | 456 | 655 | 456 | 285 | 199 | 114 | 85 | 85 | 113 | 113 | 78 | 78 | 52 | 52 | 52 | 52 | 26 | 26 | 26 | 52 | 26 | 24 |
| **Peat** | 31 | 31 | 31 | 71 | 45 | 25 | 15 | 15 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gaseous Fuels** | 14195 | 13945 | 1380 | 670 | 739 | 641 | 699 | 566 | 599 | 500 | 505 | 712 | 702 | 850 | 1014 | 841 | 806 | 764 | 587 | 521 | 977 | 808 | 1044 | 1066 | 1017 |
| **Biomass** | 1220 | 1229 | 1271 | 1306 | 1307 | 358 | 365 | 617 | 648 | 665 | 590 | 546 | 508 | 506 | 607 | 552 | 534 | 713 | 324 | 722 | 569 | 500 | 727 | 1002 | 1001 |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gasoline** | 1628 | 132 | 132 | 132 | 132 | 88 | 88 | 88 | 44 | 44 | 44 | 11 | 17 | 44 | 44 | 44 | 44 | 44 | NO | NO | NO | 88 | 88 | 88 | 46 |
| **Diesel oil** | 6161 | 8583 | 6161 | 5269 | 4419 | 3951 | 3909 | 3654 | 3229 | 3399 | 3442 | 3739 | 3399 | 3994 | 4079 | 4164 | 4461 | 4504 | 4079 | 4122 | 4462 | 4589 | 4121 | 4164 | 4248 |
| **RFO** | 1421 | 1339 | 974 | 1217 | 1258 | 487 | 691 | 285 | 203 | 244 | 244 | 244 | 244 | 244 | 203 | 162 | 41 | NO | NO | NO | 3 | 3 | NO | NO | NO |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LPG** | 46 | 46 | NO | 91 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 46 | 45 | 13 | 45 | 46 | 48 | 47 |
| **Other kerosene** | 86 | 86 | 43 | 43 | 43 | NO | 43 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid** | 126 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | 1081 | 939 | 541 | 456 | 655 | 456 | 285 | 199 | 114 | 85 | 85 | 113 | 113 | 78 | 78 | 52 | 52 | 52 | 52 | 26 | 26 | 26 | 52 | 26 | 24 |
| **Peat briquettes** | 31 | 31 | 31 | 31 | 15 | 15 | 15 | 15 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat** | NO | NO | NO | 40 | 30 | 10 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Natural gas** | 14195 | 13945 | 1380 | 670 | 739 | 641 | 699 | 566 | 599 | 500 | 505 | 712 | 702 | 850 | 1014 | 841 | 806 | 764 | 587 | 521 | 977 | 808 | 1044 | 1066 | 1017 |
| **Wood** | 1220 | 1229 | 1271 | 1306 | 1307 | 358 | 365 | 617 | 648 | 665 | 590 | 546 | 508 | 506 | 607 | 552 | 534 | 713 | 324 | 722 | 568 | 361 | 299 | 460 | 292 |
| **Other biogas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 91 | 358 | 474 | 604 |
| **Straws** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 14 | 14 | 46 |
| **Biodiesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1 | 48 | 56 | 54 | 59 |

## 1.A.5 Other

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.5 Other (Not elsewhere specified)** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | NO | NO | NO | NO | NO | NO | 3 | 1 | 3 | 2 | 2 | 2 | 94 | 84 | 131 | 104 | 103 | 39 | 47 | 73 | 107 | 98 | 100 | 88 | 128 |
| **Liquid Fuels** | NO | NO | NO | NO | NO | NO | 3 | 1 | 3 | 2 | 2 | 2 | 94 | 84 | 131 | 104 | 103 | 39 | 47 | 73 | 107 | 98 | 100 | 88 | 128 |
| **Solid Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Peat** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gaseous Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Biomass** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other Fossil Fuels** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gasoline** | NO | NO | NO | NO | NO | NO | 3 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 6 | 1 | 5 | 1 | 0 | NO | NO | NO | NO |
| **Diesel oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 75 | 65 | 111 | 77 | 73 | 14 | 21 | 49 | 87 | 80 | 79 | 63 | 105 |
| **Jet fuel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 17 | 17 | 17 | 24 | 24 | 24 | 21 | 23 | 20 | 18 | 21 | 24 | 23 |

## Energy losses, statistical differences, transfers and secondary production of products in Energy sector, TJ

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Statistical differences** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Shale oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1102 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gasoline** | NO | NO | NO | NO | NO | NO | NO | NO | NO | 6380 | 2508 | 2464 | 2948 | 747 | 528 | 264 | 440 | NO | NO | 132 | 835 | 883 | 510 | 309 | 352 |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Other kerosene** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 346 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Diesel** | NO | NO | NO | 255 | 2082 | 2719 | 425 | 1360 | 1232 | 2209 | 5141 | 1785 | 3569 | 3909 | 3782 | 4589 | 5949 | 5355 | 4334 | 7649 | 9634 | 5781 | 1360 | 2228 | 383 |
| **RFO** | NO | 1177 | 162 | 41 | NO | NO | NO | NO | NO | 650 | 974 | NO | 1421 | 325 | 284 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other liquid fuels** | 167 | 122 | 122 | 81 | 84 | 42 | 126 | 167 | 126 | 42 | 42 | 42 | NO | 84 | 42 | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Natural gas** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 101 | 438 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 275 | NO |
| **Transfer** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Shale oil** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 669 | 1102 | 826 | 79 | NO | NO | NO | NO | NO |
| **Jet fuel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 2636 | 4623 | 43 | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other kerosene** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 130 | 86 | 43 | 129 | 216 | NO | NO | NO | NO | NO | NO |
| **Diesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 340 | 127 | 127 | 212 | NO | NO | NO | NO | NO | NO |
| **RFO** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 8120 | 11815 | 853 | 1218 | 893 | 122 | NO | NO | NO | NO | NO |
| **Other liquid fuels** | 167 | 122 | 122 | 81 | 84 | 42 | 126 | 167 | 126 | 42 | 42 | 42 | NO | 84 | 42 | 42 | 42 | 42 | 42 | 42 | NO | NO | NO | NO | NO |
| **Losses** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **LPG** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 46 | 46 | 46 | 46 | 46 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Diesel** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 127 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Gasoline** | 44 | 44 | 44 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Coal** | 114 | 114 | 114 | 57 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 26 | NO | NO | NO | NO | 1 | NO |
| **Peat** | 70 | 20 | 10 | 30 | NO | NO | NO | NO | 10 | 10 | 60 | NO | NO | 241 | 10 | NO | NO | NO | 40 | 10 | 60 | NO | NO | 20 | NO |
| **Natural gas** | 136 | 1625 | 1481 | 1434 | 1004 | 977 | 999 | 1032 | 1032 | 999 | 673 | 472 | 572 | 740 | 536 | 167 | 268 | 335 | 336 | 639 | 269 | 505 | 505 | 275 | 588 |
| **Secondary Production** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Other liquid fuels** | NO | NO | NO | NO | NO | NO | 1088 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Other fossil fuels** | 42 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 419 | 292 | 88 | 292 | 205 | 234 | 263 | 88 | 66 | 29 | 29 | 29 | 29 |

**A.3.2. Energy Detailed discussion of methodology and data for estimating CO2 emissions from fossil fuel combustion**

# Guidance manual for $CO_2$ emission estimations

(Developed in accordance with UNFCCC and IPCC recommendations and physical characteristics of fuels used in Latvia)

V.Bergmanis

Riga 2004

**Annotation**

The report is done in accordance with conditions of contract No. 15 of 17 May 2004. Guidance manual of $CO_2$ emissions from stationary fuel combustion installations estimations is developed in accordance to requirements from IPCC Guidelines. It means that according to developed guidance, $CO_2$ emissions from every object could be determined using physical characteristics of combusted fuel and amount of consumed fuel. In case such physical characteristics are not available, average estimated data for types of fuels used in Latvia could be used (Table 1).

Following additional information are given:

capacity of combustion installations,

particle content of fuel,

concept of heat of combustion and use of it in estimations

discretion in composition of thermal balance of combustion installation that provide better understanding of combustion installations operations and processes that generate $CO_2$ emissions.

The report is developed to help enterprises that operate with combustion installations, Regional Environmental Boards (REB) and environment experts calculate $CO_2$ emission from stationary fuel combustion.

## Introduction

Guidance for practical determination of $CO_2$ emission factors in the case of:

combusted type of fuel and physical qualities of it;

combusted amount of fuel,

is developed for enterprises to fulfil the requirements of national legislation (Cabinet of Ministers Regulations "About taxes of natural resources" and Cabinet of Ministers Regulation No. 555).

Stationary combustion installations are divided in:

boiler units – generation of electricity and heat for public utilities;

technological equipment combustion installations that are divided in:

installations where flue gases directly do not collide with produced products (mainly food industry – bread baking, malt drying;

Installations where flue gases directly collide with produced products (construction materials and metal production).

In point 1 and 2.1 mentioned installations emission thresholds of noxious products are determined and guidance of $CO_2$ emission estimations could be used. In other cases technological specific of production should be taken into account.

Mathematical expression of $CO_2$ emission determination given in first chapter is used in specified calculation using data from fuel certificates and combusted amount of fuels. In cases when data from fuel certificates are not available (carbon content and net calorific value of fuel), $CO_2$ emission factors (Table 1) that are estimated using mathematical expression, IPCC Guidelines and average values of physical qualities of fuels used in Latvia are used.

In $CO_2$ emission determination it is assumed that all carbon stored in fuel transforms into $CO_2$ in combustion process. Practically part of carbon (depends on type of fuel, type of furnaces, maintenance conditions of boiler units) doesn't burn fully and forms CO that transforms into $CO_2$ in length of time (approximately 48 h).

Consequently enterprise operating combustion installation and permit chemically incomplete combustion ($q_3$) has to consume bigger amount of fuel to obtain necessary amount if heat and therefore bigger amount of $CO_2$ is generated.

Part of fuel did not participate in combustion processes. This part is composed by non-combusted fuel (carbon) that is discharged from combustion installation with ashes, slag and soot. Non-combusted part of fuel is accounted as mechanically incomplete combustion losses $q_4$ in thermal balance of combustion installation. These loses are rather big if solid fuels – coal, peat, are combusted (ashes, slag), smaller – if liquid fuels are combusted (soot) and minimal – if gaseous fuels are combusted. For gaseous fuels $q_4$ is technological losses (maintenance of installations and safe work requirements provision) that are gas-fittings leakage in units processes to avoid possible explosions. In leakage process other greenhouse effect gas – methane, is emitted to atmosphere.

Brief discretion in particle content of organic fuel, relevance between fuel working, dry and combusted volumes, gross and net calorific values and suggestions in what cases previously mentioned relevancies could be used in estimations are given in the report.

## 1. $CO_2$ emission estimations for combusted organic fuels (guidance manual)

In combustion of organic fuels process carbon (C) in fuel connects with air oxygen as a result carbon dioxide ($CO_2$) is made. In case of chemically incomplete combustion also carbon monoxide (CO) is made that in approximately 48 h time connects with air oxygen and transforms in $CO_2$.

To estimate $CO_2$ emissions, it is necessary to know:

- combusted type of fuel;
- amount of combusted fuel $B_n$;
- carbon content ($C^d$ %) in working mass of fuel;
- net calorific values of working mass of fuel ($Q_z^d$, MJ/kg ($m^3$)).

Easier way to estimate $CO_2$ emissions is to calculate emission factor (E) and consumed amount of fuel ($B_q$) marked in heat amount units (MJ, GJ, TJ…. / time period). For E and $B_q$ estimation necessary data is collected from fuel certificates (Quality note) or analyse data and accounting of combusted fuels.

**For emission factor calculation following relevance is used:**

$$EF_{CO_2} = \frac{C^d \times M_{CO_2} \times 1000}{Q_z^d \times M_C \times 100} = \frac{C^d}{Q_z^d} \times 36,6413$$

*where:*

*$EF_{CO2}$ – emission factor for $CO_2$ (kg $CO_2$/MJ)*
*$Q_z^d$ – net calorific value of fuel (MJ/kg ($m^3$))*
*$C^d$ – carbon content in fuel (%)*
*$M_{CO_2}$ – molecule weight for $CO_2$ – 44, 0098 (g/mcl)*
*Mc – molecule weight for C – 12,011 (g/mcl)*
*1000 – switching from MJ to GJ*
*100 – percentage determination*

Heat amount generated into furnaces with fuel is estimated:

$$B_q = B_n \times Q_z^d$$

*where:*

*Bn – consumption of fuel in natural units in time period, tn ($10^3 \square m^3$)*
*$CO_2$ emissions in time period are estimated:*

$$CO_2 = E_{CO_2} \times B_q$$

*where:*
*$CO_2$ – estimated emissions, kg (t)*
*$E_{CO2}$ – calculated emission factor, kg/GJ (t/TJ)*
*$B_q$ - heat amount generated into furnaces with fuel, GJ (TJ)*

Practically all amount of fuel input in furnaces doesn't take part in combustion process. Part of non-combusted fuels is discharged from furnace with ashes, soot and slag. These are so-called mechanically incomplete combustion losses. That's why oxidation factor p has to be taken into account in $CO_2$ emission estimations.

**Oxidation factor:**

$$p = \frac{100 - q_4}{100}$$

**Practically $CO_2$ emissions:**

$$E'_{CO_2} = E_{CO_2} p$$

If data from fuel certificates are not available, average data summarized in Table 1 could be used in $CO_2$ emission estimations. Data reported in table are estimated by using average data from fuel certificates of fuels used in Latvia and suggestions from IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

**Table 1 Carbon content in organic fuels working masses, net calorific values and $CO_2$ emission factor**

| Type of fuel | Carbon content $C^d$ % | NCV ($Q_z^d$) MJ/kg | Emission factor without oxidation factor (E $CO_2$) kg/GJ | Oxidation factor (p) | Emission factor with oxidation factor (EF $CO_2$) kg/GJ |
|---|---|---|---|---|---|
| Wood, $W^d$ = 55% | 20.11 | 6.70* | 109.98 | 0.98 | **107.78** |
| Peat, $W^d$ = 40% | 29.07 | 10.05 | 105.98 | 0.98** | **103.87** |
| Residual fuel oil | 85.72 | 40.60 | 77.36 | 0.99 | **76.59** |
| Gasoline (used in offroads***) | 93.13 | 44 (1990-2001)<br>43.97 (2003-2014) | 88.75<br>87.36 | 0.99 | **68.53**<br>**68.58** |
| Diesel oil, liquid oven fuel | 86.68 | 42.49 | 74.75 | 0.99 | **74.00** |
| Natural gas | Changes annually; see Chapter 3.2.4.2 | | | 0.995 | **Changes annually** |
| LPG | 77.99 | 45.54 | 62.75 | 0.995 | **62.44** |
| Shale oil | 82.82 | 39.35 | 77.12 | 0.99 | **76.35** |
| Other kerosene | 85.17 | 43.20 (1990-2000)<br>43.21 (2004)<br>43.2 (2005-2014) | 72.24<br>72.22 | 0.99 | **71.52**<br>**71.50** |
| Jet fuel | 85.18 | 43.2 (1990-2002)<br>43.21 (2003-2014) | 72.25<br>72.23 | 0.99 | **71.53**<br>**71.51** |

* for wood – $Q_z^d$ ir TJ/1000m$^3$

** natural gas – $Q_z^d$ is MJ/m$^3$

**** off roads – vehicles not involved in traffic, for example, asphalt pavers, and other commercial and household technological equipment, for example, grass rollers

Emission factor values ($E^nCO_2$) that are determined for natural unit of consumed amount of fuel – t, (1000 $m^3$) could be used equally in $CO_2$ emission estimations. These values are reported in Table 2.

**Table 2 $CO_2$ emission factors for natural units of organic fuel**

| Type of fuel | $E^nCO_2$, kg/t (1000 $m^3$) |
|---|---|
| Wood, $W^d$ = 55% | 722 |
| Peat, $W^d$ = 40% | 1044 |
| Residual fuel oil | 3110 |
| Diesel oil, liquid oven fuel | 3144 |
| Motor gasoline (for off-roads) | 3016 |
| Natural gas | 1879 |
| LPG | 2844 |
| Shale oil | 2968 |
| Other kerosene | 3090 |
| Jet fuel | 3089 |

Following relevance for very approximate (control) $CO_2$ emission estimations could be used:

$$E_k \approx \frac{B_n \times C^d \times M_{CO_2}}{M_C \times 100} \approx B_n \times C^d \times 0{,}0366413$$

*where:*
*$B_n$ – consumed natural units amount of fuels, t (1000 $m^3$)*
*$C^d$ – carbon content in working mass of fuel, %*

*Note: $CO_2$ emissions of renewable energy resources are not estimated. Emission factors given in Table 1.1 and Table 1.2 could be used as comparative values.*

## 4. Explanation and suggestions

1. In IPCC methodology it is determined that in each country all available data have to be used in estimation of $CO_2$ emission factors for different fuel types and only when these data aren't available data from methodology could be used. It was taken into account when $CO_2$ emission factors for fuels used in Latvia were estimated.

2. Country's average $CO_2$ emission factors are estimated using actual data of fuel consumption and types [L1 chapter 1.2.1]. These data are obtained by Central Statistical Bureau of Latvia. Also in L1 it is stated that only part of fuel consumption used for acquisition of Energy has to be taken into account instead of the part that is used in technological processes. In the same chapter it is stated that amount of all combusted fuel types has to be estimated by using the same output measures. In the energy balance prepared by Central Statistical Bureau fuel consumption is estimated by using net calorific value of working volume of each particular type of fuel $Q_z^d$, but for natural gas – gross calorific value $Q_a$ (it is recommendation of EUROSTAT). It has to be taken into account in estimation of total country's $CO_2$ emissions.

3. In total amount of $CO_2$ emissions leakage of gas (ventilation and technological losses) in the extraction fields of coal-gas aren't taken into account. It is referable to the exploitation

of natural gas utilization equipment. Oxidation coefficient for the gaseous fuels is used in the estimation of $CO_2$ emissions. Leakage of gas is accounted as fugitive $CH_4$ emissions.

5. In cases if net calorific values of fuels $Q_z^d$ aren't available but only $Q_a$ data it is possible to use average values in the estimation [L1]:

for liquid and solid fuels $Q_z^d$ ~ 0, 95 $Q_a$

for gaseous fuels $Q_z^d$ ~ 0,9 Q

## A.3.3. Energy: $CO_2$ reference approach and comparison with sectoral approach

**Table 1 Reference Approach estimations (TABLE 1.A(b))**

**TABLE 1.A(b) SECTORAL BACKGROUND DATA FOR ENERGY**

**$CO_2$ from fuel combustion activities - reference approach (IPCC worksheet fuel combustion activities)**

**(Sheet 1 of 1)**

| FUEL TYPES | | | Unit | Production | Imports | Exports | International bunkers | Stock change | Apparent consumption | Conversion factor (TJ/Unit)[1] | NCV/GCV [(2)] | Apparent consumption (TJ) | Carbon emission factor (t C/TJ) | Carbon content (kt) | Carbon stored[C excluded] (kt C) | Net carbon emissions ((kt) C) | Fraction of carbon oxidized | Actual $CO_2$ emissions ((kt) $CO_2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Liquid fossil | Primary fuels | Crude oil | TJ | NO | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Orimulsion | TJ | NO | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Natural gas liquids | TJ | NO | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | Secondary fuels | Gasoline | TJ | | 9491.00 | 912.00 | NO | -791.00 | 9370.00 | 1.00 | NCV | 9370.00 | 18.91 | 177.15 | NO | 177.15 | 0.99 | 643.05 |
| | | Jet kerosene | TJ | | 4796.00 | 173.00 | 4580.00 | NO | 43.00 | 1.00 | NCV | 43.00 | 19.71 | 0.85 | NO | 0.85 | 0.99 | 3.08 |
| | | Other kerosene | TJ | | 43.00 | 43.00 | NO | NO | 0.00 | 1.00 | NCV | 0.00 | NO | NO | NO | NO | NO | NO |
| | | Shale oil | TJ | | 79.00 | 79.00 | | NO | 0.00 | 1.00 | NCV | 0.00 | NO | NO | NO | NO | NO | NO |
| | | Gas/diesel oil | TJ | | 58254.00 | 25027.00 | 2932.00 | -4122.00 | 34417.00 | 1.00 | NCV | 34417.00 | 20.40 | 702.11 | NO | 702.11 | 0.99 | 2548.66 |
| | | Residual fuel oil | TJ | | 6821.00 | 487.00 | 6780.00 | -487.00 | 41.00 | 1.00 | NCV | 41.00 | 21.11 | 0.87 | NO | 0.87 | 0.99 | 3.14 |
| | | Liquefied petroleum gases (LPG) | TJ | | 8971.00 | 4645.00 | | 91.00 | 4235.00 | 1.00 | NCV | 4235.00 | 17.13 | 72.53 | NO | 72.53 | 1.00 | 264.60 |
| | | Ethane | TJ | | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Naphtha | TJ | | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Bitumen | TJ | | 3014.00 | NO | | 84.00 | 2930.00 | 1.00 | NCV | 2930.00 | 22.00 | 64.46 | 69.98 | -5.52 | 0.99 | -20.04 |
| | | Lubricants | TJ | | 1426.00 | 836.00 | NO | -42.00 | 632.00 | 1.00 | NCV | 632.00 | 20.00 | 12.64 | 1.00 | 11.64 | 1.00 | 42.70 |
| | | Petroleum coke | TJ | | NO | NO | | NO | NO | 1.00 | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Refinery feedstocks | TJ | | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Other oil | TJ | | 3259.00 | 2805.00 | | 42.00 | 412.00 | 1.00 | NCV | 412.00 | 20.00 | 8.24 | NO | 8.24 | 1.00 | 30.21 |
| Other liquid fossil | | | | | | | | | | | | NO | | NO | NO | NO | | NO |
| Liquid fossil totals | | | | | | | | | | | | 52080.00 | | 1038.84 | 70.98 | 967.86 | | 3515.40 |

| FUEL TYPES | | | Unit | Production | Imports | Exports | International bunkers | Stock change | Apparent consumption | Conversion factor (TJ/Unit)[1] | NCV/GCV (2) | Apparent consumption (TJ) | Carbon emission factor (t C/TJ) | Carbon content (kt) | Carbon stored[C excluded] (kt C) | Net carbon emissions ((kt) C) | Fraction of carbon oxidized | Actual $CO_2$ emissions ((kt) $CO_2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Solid fossil | Primary fuels | Anthracite(3) | TJ | NO | NO | NO | | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| | | Coking coal | TJ | NO | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Other bituminous coal | TJ | NO | 2061.00 | 145.00 | NO | -557.00 | 2473.00 | 1.00 | NCV | 2473.00 | 25.80 | 63.80 | NO | 63.80 | 1.00 | 233.95 |
| | | Sub-bituminous coal | TJ | NO | NO | NO | NO | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Lignite | TJ | NO | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Oil shale and tar sand | TJ | NO | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | Secondary fuels | BKB(4) and patent fuel | TJ | | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Coke oven/gas coke | TJ | | NO | NO | | NO | NO | 1.00 | NCV | NO | NO | NO | NO | NO | NO | NO |
| | | Coal tar | TJ | | NO | NO | | NO | NO | NO | NCV | NO | NO | NO | NO | NO | NO | NO |
| Other solid fossil | | | | | | | | | | | | NO | | NO | NO | NO | | NO |
| Solid fossil totals | | | | | | | | | | | | 2473.00 | | 63.80 | NO | 63.80 | | 233.95 |
| Gaseous fossil | | Natural gas (dry) | TJ | NO | 32733.00 | NO | | -12653.00 | 45386.00 | 1.00 | NCV | 45386.00 | 14.88 | 675.47 | NO | 675.47 | 1.00 | 2464.34 |
| Other gaseous fossil | | | | | | | | | | | | NO | | NO | NO | NO | | NO |
| Gaseous fossil totals | | | | | | | | | | | | 45386.00 | | 675.47 | NO | 675.47 | | 2464.34 |
| Waste (non-biomass fraction) | | | TJ | NO | IE | IE | NO | IE | NO,IE | IE | NCV | NO,IE | IE | NO,IE | IE | NO,IE | IE | NO,IE |
| Other fossil fuels | | | | | | | | | | | | 1294.04 | | 16.02 | NO | 16.02 | | 58.75 |
| | | Industrial waste | TJ | NO | 342.70 | NO | | -7.54 | 350.24 | 1.00 | NCV | 350.24 | 16.53 | 5.79 | NO | 5.79 | 1.00 | 21.23 |
| | | Municipal waste | TJ | NO | 929.15 | 11.15 | | 3.19 | 914.81 | 1.00 | NCV | 914.81 | 10.55 | 9.65 | NO | 9.65 | 1.00 | 35.39 |
| | | Waste oils | TJ | 29.00 | NO | NO | | NO | 29.00 | 1.00 | NCV | 29.00 | 20.00 | 0.58 | NO | 0.58 | 1.00 | 2.13 |
| Peat(5,6) | | | TJ | 50.00 | NO | NO | NO | 15.00 | 35.00 | 1.00 | NCV | 35.00 | 28.59 | 1.00 | NO | 1.00 | 0.98 | 3.60 |
| **Total** | | | | | | | | | | | | 101268.04 | | 1795.14 | 70.98 | 1724.16 | | 6276.03 |
| Biomass total | | | | | | | | | | | | 60963.71 | | 1748.31 | NO | 1748.31 | | 6287.68 |
| | | Solid biomass | TJ | 85666.00 | 2514.00 | 30678.00 | | 1782.00 | 55720.00 | 1.00 | NCV | 55720.00 | 30.01 | 1672.31 | NO | 1672.31 | 0.98 | 6009.78 |
| | | Liquid biomass | TJ | 2788.10 | 637.89 | 2465.24 | | -35.68 | 996.43 | 1.00 | NCV | 996.43 | 19.30 | 19.23 | NO | 19.23 | 1.00 | 70.51 |
| | | Gas biomass | TJ | 2974.83 | NO | NO | | NO | 2974.83 | 1.00 | NCV | 2974.83 | 13.95 | 41.51 | NO | 41.51 | 1.00 | 151.44 |
| | | Other non-fossil fuels (biogenic waste) | TJ | NO | 1286.86 | 13.86 | | 0.55 | 1272.45 | 1.00 | NCV | 1272.45 | 11.99 | 15.26 | NO | 15.26 | 1.00 | 55.95 |

## Table 2 Comparison of $CO_2$ emissions from fuel combustion (1.A(c))

**TABLE 1.A(c) COMPARISON OF $CO_2$ EMISSIONS FROM FUEL COMBUSTION**
**Comparison of $CO_2$ emissions from fuel combustion**
**(Sheet 1 of 1)**

Inventory 2014
Submission 2016 v3
LATVIA

| FUEL TYPES | REFERENCE APPROACH | | | SECTORAL APPROACH[1] | | DIFFERENCE[2] | |
|---|---|---|---|---|---|---|---|
| | Apparent energy consumption[3] (PJ) | Apparent energy consumption (excluding non-energy use, reductants and feedstocks)[4] (PJ) | $CO_2$ emissions (kt) | Energy consumption (PJ) | $CO_2$ emissions[5] (kt) | Energy consumption (%) | $CO_2$ emissions[6] (%) |
| Liquid fuels (excluding international bunkers) | 52.08 | 48.14 | 3515.40 | 51.30 | 3721.72 | -6.16 | -5.54 |
| Solid fuels (excluding international bunkers) | 2.47 | 2.47 | 233.95 | 2.47 | 233.95 | -0.01 | 0.00 |
| Gaseous fuels | 45.39 | 45.39 | 2464.34 | 44.80 | 2430.72 | 1.31 | 1.38 |
| Other fossil fuels | 1.29 | 1.29 | 58.75 | 1.28 | 109.70 | 1.20 | -46.44 |
| Peat | 0.04 | 0.04 | 3.60 | 0.03 | 3.59 | 0.42 | 0.20 |
| ***Total***[5] | 101.27 | 97.33 | 6276.03 | 99.88 | 6499.67 | -2.56 | -3.44 |

## A.3.4. Fugitive emissions

**METHODOLOGY FOR CALCULATION OF TECHNOLOGICAL LOSSES OF NATURAL GAS IN INČUKALNS UNDERGROUND GAS STORAGE FACILITY (IUGSF)**

In order to calculate losses of natural gas, it is necessary to determine the territory where it is stored. Inčukalns Underground Gas Storage Facility (IUGSF) consists of underground geological formations where natural gas is stored, underground and surface technological equipment with whose assistance gas from the Transport (Main) pipeline is injected into the "gas-bearing" underground layer and received from it. IUGSF border with the Transport (Main) pipeline system is the IUGSF access node to the Transport (Main) pipeline system.

In many cases calculation of technological losses of natural gas are grounded with the gas loss standards. These standards are determined based on the normative technical documentation that is related to the technical equipment at the respective time.

Technological losses of natural gas are calculated in standard conditions: gas temperature 200C, pressure 760 mm Hg. Quantities used in the calculations are obtained based on the current technological equipment and as a result of practical measurements.

In general, the amount of technological losses of natural gas depends on the technical condition of gas system.

**<u>1. Calculation of natural gas losses with gas release into the atmosphere without burning it:</u>**

**1.1. Purging technological pipelines, connective pipelines with gas in order to clear them from hydrate formations, oil, mud and water.**

In order to clear technological pipelines, connective pipelines from hydrate formations, oil, mud and water, it is necessary to purge them with gas. This operation is done at the gas collection points (GCP) by conveying gas into the Transport (Main) gas pipeline system.

Nonetheless, sometimes in practice it is necessary to release gas into the atmosphere because of technical and technological reasons. In these cases losses of natural gas are calculated using the following formula:

$$Q_{gas} = 0.0307 \frac{(p_a + p_g) F \tau}{\rho \sqrt{273.15 + t_g}}$$ ($m^3$) where

$P_a$– atmospheric pressure, MPa;
$P_g$– gas pressure in technological pipelines, connective pipeline, MPa;
F– area of gas release opening, $mm^2$;
τ– gas leak time, s;
ρ– gas density in standard conditions, $km/m^3$($0.685\ km/m^3$);
$t_g$– gas temperature, 0C.

**1.2. Releasing condensate collectors, contactors, separators, filter-separators and filters form condensate.**

Amount of natural gas losses that occurs when removing condensate from condensate collectors, contactors, separators, filter separators and filters is determined by the amount of condensate in which gas has dissolved and additional amount of gas removed from the equipment.

Total amount of gas losses that occurs when releasing condensate collectors, contactors, separators, filter separators and filters from condensate are calculated using the following formula:

$$Q_{gas} = 1692\frac{p_a + p_g}{273.15 + t_g}V_k + 0.133F\frac{p_a + p_g}{Z(273.15 + t_g)}\tau$$ $m^3$ where

$Q_{gas}$– losses of natural gas occurred when releasing condensate collectors, contactors, separators, filter-separators and filters form condensate, $m^3$ ;
$P_a$ – atmospheric pressure, MPa (0.1 MPa);
$P_g$– gas pressure in condensate collector, contactor, separator, filter-separator, filter, MPa;
F – area of gas release opening, $mm^{2;}$
$t_g$– gas temperature, $^0C$;
$V_k$– amount of removed condensate, $m^3$ ;
τ– condensate release time, s;
Z – gas compressibility factor (in condensate collector, contactor, separator, filter-separator, filter).

### 1.3. Starting gas motor compressor.

Amount of natural gas losses that occurs when starting motor compressor is determined by the consumed amount of natural gas. For starter motor that spins engine crankshaft with gas. To spin auxiliary turbines that spin basic turbines with gas in order to ensure air supply in cylinders. For operation of oil pump with gas in order to ensure oiling of compressor during the time of its launch.

1.3.1. Amount of natural gas consumed for starter motor that spins crankshaft:

$$Q_{gas_{st.}} = 0.0307\frac{(p_a + p_g)F\tau}{\rho\sqrt{273.15 + t_g}}$$ ($m^3$).

$P_a$– atmospheric pressure, MPa;
$P_g$– pressure of natural gas to spin starter motor $P_g$= 1.8 MPa
F– area of gas release opening, $mm^2$;
τ– gas leak time, s;
ρ– gas density in standard conditions, $km/m^3$(0.685 $km/m^3$);
$t_g$– gas temperature, 0C.

1.3.2. Amount of natural gas consumed to start auxiliary turbines that are spun with gas by the basic turbines in order to ensure air supply in cylinders is calculated with the following formula (1).

Calculations are similar to the paragraph 1.3.1. Differences are the following:

Natural gas pressure, Pg = 0.15 MPa ; Cross-section area thought which gas flows out.

1.3.3. Amount of natural gas consumed to operate oil pumps is calculated with the following formula (1).

Calculations are similar to the paragraph 1.3. Gas pressure, Pg= 0.3 MPa ;

Total amount of natural gas consumed to start motor compressor $Q_{tostartcompr.}$ is calculated by summarizing natural gas consumption paragraphs 1.3:

$$Q_{tostartcompr.} = Q_{gastostart} + Q_{gasinaddturb.} + Q_{gasoilp.}$$ ($m^3$).

### 1.4. Releasing gas motor compressor and gas air cooling equipment from gas.

Losses of natural gas occur at the end of injection period when gas motor compressors and air cooling equipment is released from gas (end of October, beginning of November) when operation of previously mentioned equipment is stopped and released from gas.

Amount of natural gas losses that occurs in the process when motor compressors and gas air cooling equipment is released from gas is calculated with the following formula:

$$Q_{rel} = V\frac{P_{equip}T_{st}}{P_{st}T_{equip}Z}$$ ($m^3$) where

$Q_{rel}$– natural gas losses that occur when fully releasing gas pipelines and equipment from gas, $m^3$;
V – internal geometric volume of pipelines and equipment, $m^3$;
$T_{st}$– temperature of natural gas in standard conditions, K;
$T_{equip}$– temperature of natural gas in pipelines and equipment, K ;
$P_{equip}$ – absolute pressure of natural gas in gas pipelines and equipment, MPa ;
$P_{st}$ – absolute pressure of natural gas in standard conditions. MPa (≈0.1MPa) ;
Z – compressibility factor of natural gas at pressure $P_{equip}$ and temperature $T_{equip}$.

**1.5. Releasing condensate collectors, contactors, separator, filter-separators and filters from gas.**

In order to perform maintenance and examination of the mentioned equipment, equipment must be released from gas. When calculating amounts of natural gas, previously mentioned equipment can be divided into two groups - equipment that is related to the compressor facility, equipment that is related to gas collections points.

<u>1.5.1. Calculation of natural gas losses for gas purification equipment that is related to the compressor facility.</u>

Those are the following - dust receivers (3 pieces), filter-separators (3 pieces).

Amount of natural gas losses that occurs when releasing equipment from gas is calculated using the following formula:

$$Q_{rel.} = V\frac{P_{equip}.T_{st.}}{P_{st}T_{equip}.Z}\ (m^3).$$

$Q_{rel}$– natural gas losses that occur when fully releasing gas pipelines and equipment from gas, $m^3$;
V – internal geometric volume of pipelines and equipment, $m^3$;
$T_{st}$– temperature of natural gas in standard conditions, K;
$T_{equip}$– temperature of natural gas in pipelines and equipment, K ; T=10$^0$C
$P_{equip}$ – absolute pressure of natural gas in gas pipelines and equipment, MPa ; $P_{equip}$=4.0 MPa
$P_{st}$ – absolute pressure of natural gas in standard conditions. MPa (≈0.1MPa) ;
Z – compressibility factor of natural gas at pressure $P_{equip}$ and temperature $T_{equip}$. Z=0.92

<u>1.5.2. Calculation of natural gas losses for gas purification equipment that is related to gas collection points (GCP).</u>

GCP-1 -Condensate collectors (12 pieces), contactors (12 pieces).

GCP-2 - First degree separators (9 pieces), first degree gas separators (10 pieces), second degree gas separators (5 pieces).

GCP-3 -First degree separators (14 pieces), first degree separators (16 pieces), second degree gas separators (8 pieces).

Decrease of gas pressure in gas purification equipment that is related to gas collection points is done by burning gas through "candle". It is practically equal with internal geometric volume of equipment and is calculated with the following formula:

$$Q_{rel.} = V_{equip.}(m^3).$$

By observing volume of circuits and frequency of maintenance, permissible loss of natural gas for the previously mentioned equipment.

**1.6. Partial decrease of gas pressure in pipelines and equipment.**

Partial decrease of gas pressure in gas pipelines and equipment is done according to the requirements of safety rules related to gas pressure in gas pipelines and equipment – if repair works are carried out nearby, decreasing gas pressure in them. Amount of natural gas losses that occurs when partly decreasing gas pressure in gas pipelines and equipment is calculated using the following formula:

$$Q_{red.} = \frac{VT_{st.}}{P_{st.}T_g}\left(\frac{P_{abs.}}{Z_{abs.}} - \frac{P_{atl.}}{Z_{atl.}}\right)(m^3)$$ where:

$Q_{red}$– natural gas losses that occur when partly decreasing gas pressure in pipelines and equipment, $m^3$ ;
V – internal geometric volume of gas pipeline (equipment) in which gas pressure is decreased, $m^3$ ;
$T_{st}$– temperature of natural gas in standard conditions, K;
$P_{st}$– pressure of natural gas in standard conditions, MPa ;
$T_g$– temperature of natural gas in pipeline (equipment), K ;
$P_{abs}$– pressure of natural gas in pipeline (equipment) before it is decreased, MPa ;
$Z_{abs}$– compressibility factor of natural gas at gas pressure $P_{abs}$ and temperature $T_g$
$P_{atl}$– pressure of natural gas in pipeline (equipment) after it is decreased, MPa ;
$Z_{atl}$– compressibility factor of natural gas at gas pressure $P_{atl}$ and temperature $T_g$.

**1.7. Releasing air from gas separators, filter-separators, dust receivers, contact lines, connective pipelines (gas purification equipment, system).**

When filling gas pipelines and equipment with gas, certain amount of gas – air mixture is released. Gas pipelines and equipment is filled with gas under low gas pressure. When carrying out these operations, losses of natural gas are calculated using the following formula:

$$Q_{mixture} = 2V(m^3)$$ where:

$Q_{mixture}$– losses of natural gas that occur when releasing separators, dust receivers, contractor lines, connective pipeline from air, $m^3$;
V – internal geometric volumes of separators, filter-separators, dust receivers, contractor lines, connective pipelines, $m^3$;

**1.8. Examinations of safety drain valves.**

In order to examine operation of safety drain valves, they are examined. Amount of natural gas losses that occurs when carrying out examinations of safety drain valves is calculated using the following formula:

$$Q_{s.v.} = \frac{BF_{s.v.}\tau P_m n}{TZ} + C_k$$ where:

$Q_{s.v.}$ – losses of natural gas that occur when carrying out examination of safety drain valves, $m^3$;
B – factor 9.16 ;
$F_{s.v.}$ – cross-section area of safety drain valve mounting, $cm^2$ ;
τ– time of safety leak valve actuation, s ;
$P_m$– pressure of natural gas, $kgf/cm^2$;
n – number of safety drain valve actuations (examinations);
T – temperature of natural gas, K ;
Z – compressibility factor of natural gas ;
$C_k$– factor (pressure of natural gas at the safety drain valve actuation exceeding: setting pressure of actuation, $C_k$ =1.65; at the safety drain valve manual actuation, $C_k$ =3.2).

**1.9. Closing and opening of valving.**

Part of the valving has a pneumatic actuator that is operated with gas. After the opening or closing (maneuver) of valving, natural gas from the pneumatic actuator is released into the atmosphere. Amount of natural gas losses occurred by opening or closing of the valving is calculated using the following formula:

$Q_n = Gn$ where:

$Q_n$- losses of natural gas occurred when opening or closing the valving (shift, day, month, quarter, year), $m^3$;
G – consumption of natural gas that occurred when carrying out one maneuver of valving (opening or closing), $m^3$;
n – number of valving maneuvers (opening or closing).

**1.10 Geophysical research (neutron-gamma logging).**

When carrying out geophysical research (borehole neutron-gamma logging), radioactive element with a wire is let into a borehole with a special auxiliary device that is installed on the fountain fitting of the borehole. Gradually radioactive element is moved upwards and geophysical research of borehole is carried out. Amount of natural gas losses that occur when carrying out research (neutron-gamma logging of borehole) is calculated with the following formula:

$$Q_{gas} = 106 \frac{(p_a + p_g)F\tau}{\rho\sqrt{273.15 + t_g}}$$ $m^3$ at $(p_a + p_g)/p_a \geq 1.84$ where:

$Q_{gas}$- losses of natural gas that occur when carrying out research (neutron-gamma logging of borehole), $m^3$;
$P_a$- atmospheric pressure, MPa ;
$P_g$- gas pressure, MPa ;
τ- time of gas leak , h;
ρ- density of gas, $kgf/m^3$ (0.685 $kgf/m^3$) ;
$t_g$- gas temperature, $^0C$;

In order to calculate gas loss, area of opening through which gas is flowing out must be known. It is calculated using the following formula:

$$F = \frac{\pi D^2}{4} - \frac{\pi d^2}{4}$$ ($mm^2$) where:

D – diameter of gasket, mm;
d – diameter of wire, mm.

**2. Calculation of burned amount of natural gas.**

Amount of natural gas that can be burned through "candle" is made from gas amounts at gas collection points (GCP), condensate collectors, contactors and separators that after equipment maintenance is released through candle, reducing gas pressure to atmospheric pressure.

In order to not complicate calculations the remaining amount of gas in equipment, after gas is burned through "candle", is considered equal with internal geometric volume and burned gas amount is calculated using the following formula:

$$Q_{burn} = \frac{VT_{st}}{P_{st}T_g}\frac{P_{abs}}{Z_{abs}} - V(m^3)$$ where:

$Q_{burn}$- amount of gas that is burned when reducing amount of gas in GCP equipment, $m^3$;
V – internal geometric volume of equipment in which gas pressure is decreased, $m^3$;
$T_{st}$– temperature of natural gas in standard conditions, K (293.15 K);

$P_{st}$– pressure of natural gas in standard conditions, MPa;
$T_g$– temperature of natural gas in pipeline (equipment), K;
$P_{abs}$– pressure of natural gas in equipment before it is decreased, MPa;
$Z_{abs}$– compressibility factor of natural gas at gas pressure $P_{abs}$ and temperature $T_g$

By taking into account the volume of gas collection point circuits, gas pressure and temperature in them, as well as frequency of maintenance, permissible amount of burned gas per year, decreasing gas pressure in GCP equipment, is calculated with the following conditions:

GCP-1 -Condensate collectors (12 pieces), contactors (12 pieces).

GCP-2 - First degree separators (9 pieces), first degree gas separators (10 pieces), second degree gas separators (5 pieces).

GCP-3 -First degree separators (14 pieces), first degree separators (16 pieces), second degree gas separators (8 pieces).

Factual amount of burned gas is calculated at factual gas pressures and temperatures in equipment. Methodology of the given calculation is used to calculate amounts of burned gas – if necessary, releasing technological pipelines from gas.

**3. Calculation of technological losses of natural gas from gas leaks.**

Losses of natural gas from leaks occur of gas leaks at gas pipeline unit shut-off devices, fountain fitting, as well as leakages in compressors and intercolumns. When calculating losses of natural gas from gas leaks at gas pipeline unit shut-off devices, fountain fitting and leakages in compressors, data from the common researches of the U.S. Gas Research Institute and Environmental Protection Agency were used.

**3.1. Amount of natural gas losses from leaks in gas pipeline line part shut-off devices is calculated using the following formula:**

$$Q_n = Q_{con} N_{con} + Q_{gal} N_{gal} \left(\frac{m^3}{a}\right)$$ where:

$Q_n$- losses of natural gas from leaks in gas pipeline unit shut-off devices, $m^3/a$;
$Q_{con}$- average amount of gas leak in the gas pipeline unit shut-off device, 24.55 $m^3/a$;
$N_{con}$- amount of gas pipeline unit shut-off devices (except of candle valves), pcs. ;
$Q_{con}$ - average amount of gas leak in gas pipeline unit "candle" valve, 317.2 $m^3/a$;
$N_{gal}$- amount of gas pipeline unit "candle" valves, pcs.

**3.2. Natural gas losses from gas leaks thought compressor leakages are calculated using the following formula:**

$$Q_{c.g} = Q_{compressorgaskets} N \left(\frac{m^3}{a}\right)$$ where:

$Q_{c.g}$– average losses of natural gas from compressor gas leaks, $m^3/a$;
$Q_{compressorgaskets}$– average losses of natural gas (with compressor operating non-stop) because of leaks through compressor gaskets per year, 8496 $m^3/a$;
N – amount of operating motor compressors, pcs.

**3.3. Amount of natural gas losses from gas leaks in fountain fitting is calculated using the following formula:**

$$Q_{f.a} = Q_{clos} N_{clos} + Q_{candlevalves} N_{candlevalves} \left(\frac{m^3}{a}\right)$$ where:

$Q_{f.a}$– average losses of natural gas from leaks in fountain fitting, $m^3/a$;

$Q_{clos}$ – average amount of gas leaks in shut-off device of fountain fitting (except of "candle" valves), 26 $m^3/a$;
$N_{clos}$– number of shut-off devices of fountain fitting (except of "candle" valves), pcs.;
$Q_{candlevalues}$– average amount of gas leaks in "candle" valves of fountain fitting, 6.71 $m^3/a$;
$N_{candlevalues}$ – amount of "candle" valves of fountain fitting, pcs.

These losses of natural gas occur from leaks in shut-off devices of fountain fitting.

**3.4. The amount of gas losses of intercolumns Qst. is calculated in accordance with indications of gas meter.**

Amount of natural gas leaks that occur in intercolumns are measured with gas meters. That is why given amount is calculated using indications of gas meters. Amount of natural gas leaks in intercolumns in the IUGSF is measured and recorded by the Geological Department of IUGSF.

**4. Calculation of losses of natural gas without gas leaks into the atmosphere.**

It consists of the amount of natural gas that is necessary to fulfil internal geometric volume of gas pipelines and equipment, as well as to reach operating pressure. Natural gas losses are calculated using the following formula:

$$Q_{gas} = \frac{VP_{abs}T_{st}}{P_{st}T_g Z}$$ ($m^3$) where:

$Q_{gas}$– losses of natural gas that occur when filling pipelines and equipment with gas after construction works will be finished and they will be put into operation, $m^3$ ;
V – geometric volume of gas pipeline, equipment , $m^3$ ;
$P_{abs}$– absolute pressure of natural gas in the gas pipeline, equipment after injection of gas, $kgf/cm^2$;
$T_{st}$– absolute temperature in standard conditions, K (293.15 K);
$P_{st}$– gas pressure in standard conditions, $kgf/cm^2$; (1.0332 $kgf/cm^2$;);
$T_g$– gas temperature, K;
Z – compressibility factor of gas at temperature $T_g$ and pressure $P_{abs.}$

**5. Calculation of emergency outflows (losses).**

Emergency outflows are unplanned losses of natural gas that can occur from significant damages of gas pipelines and equipment. If area of the damage is smaller than the area of pipeline cross-section and gas pressure does not decrease, then natural gas losses, Qgas are calculated using the following formula:

$$Q_{gas} = 106\frac{(p_a + p_g)F\tau}{\rho\sqrt{273.15 + t_g}} \text{ m}^3 \text{ at } (p_a + p_g)/p_a \geq 1.84$$ where:

$P_a$- atmospheric pressure, MPa ;
$P_g$- gas pressure, MPa;
F – area of damaged pipeline, $mm^2$;
τ- gas leak time, h;
ρ- density of gas,$kg/m^3$;
$t_g$- gas temperature, $^0C$.

If area of damaged pipeline is comparable with cross-section area of pipeline, then gas pressure in pipeline decreases and becomes a multiple parameter function.

In this case amount of released gas is calculated using another methodology.

## METHODOLOGY FOR CALCULATION OF TECHNOLOGICAL LOSSES OF NATURAL GAS IN THE TRANSPORT (MAIN) GAS PIPELINE SYSTEM

In order to calculate losses of natural gas, it is necessary to determine the territory where it is stored. Transport (Main) gas pipeline system has borders with: neighbouring countries has state border, Inčukalns Underground Gas Storage Facility (IUGSF) has access node to the Transport (Main) gas pipeline system, distribution system has gas regulation station (GRS) fence above the GRS exit pipes.

Calculation of losses of natural gas in many cases is grounded with gas loss standards. At the moment, modernisation, change of valves in the line and other works of gas regulator stations (GRS) are carried out. In order to use energy most efficiently, amount of gas to be released into the atmosphere and related costs before repair works, gas pressure of pipelines, conveying gas to users, is reduced to a minimum. In general, amount of natural gas losses depends on technical condition of gas system that, according to its improvement and development process, changes continuously.

**1. Calculation of natural gas losses that occur when releasing gas into the atmosphere without burning it:**

**1.1. Calculation of natural gas losses necessary to purge gas pipeline with gas – after it is put into operation after construction works, as well as repair works, installations or other works are done and gas pipeline was released from gas.**

Amount of natural gas losses are calculated using the following formula:

$$Q_{gas} = 5786 V_{sist} \frac{P_{purg}}{273.15 + t_g}$$ ($m^3$) where:

$Q_{gas}$– losses of natural gas that occur when purging gas pipeline with gas – after it is put into operation after construction works, as well as repair works, installations or other works are done and gas pipeline was released from gas, $m^3$;
$V_{sist}$– internal geometric volume of gas pipeline , $m^3$;
$P_{purg}$– pressure of gas purged through the pipes, MPa;
$t_g$– gas temperature during the release, $^0C$ (average amount after measurements − 7 $^0C$).

**1.2. Calculation of natural gas losses that occur when releasing gas pipeline from gas before repair works or other works when it has to be completely free from gas.**

It consists of the remaining amount of gas in the geometric volume of gas pipeline at the atmospheric pressure. Amount of natural gas is calculated using the following formula:

$$Q_{gas} = 2893 \frac{V_{sist} p_a}{(273.15 + t_g) 0.998}$$ ($m^3$) where:

$Q_{gas}$– losses of natural gas that occur when releasing gas pipeline from gas, $m^3$;
$V_{sist}$– internal geometric volume of gas pipeline, $m^3$;
$P_a$– atmospheric pressure, MPa (0.1MPa) ;
**$t_g$– gas temperature, (average amount after measurements − 7 $^0C$).**

**1.3 Calculation of natural gas losses that occur when decreasing gas pressure at gas regulation stations (GRS) in order to release equipment and communications from gas completely.**

It consists of gas from gas pipelines and equipment released into the atmosphere after pressure of gas in them has been decreased (when conveying gas to consumers) to the pressure at the GTS exit. Amount of natural gas losses is calculated with the following formula:

$$Q_{gas} = 2893 \frac{V_{sist} (p_a + p_g)}{(273.15 + t_g) K_z}$$ ($m^3$) where:

$Q_{gas}$- losses of natural gas that occur when gas pressure at gas regulation stations (GRS) is decreased, $m^3$;
$V_{sist}$- internal geometric volume of gas pipelines and equipment, $m^3$;
$P_a$- atmospheric pressure, MPa (0.1 MPa);
$P_g$- gas pressure in gas pipelines and equipment (equal with gas pressure at the exit of gas regulation stations), MPa ;

$t_g$- gas temperature, $^0$C (average amount after measurements – 7 $^0$C).
$K_z$- relative gas compressibility factor at gas pressure $P_g$.

**1.4. Calculation of natural gas losses that occur when carrying out maintenance of gas regulation stations (GRS).**

1.4.1. Calculation of natural gas losses that occur when filters, filter-separators are released from condensate.

Amount of natural gas losses that occur when releasing filters (for the new GRS) and filter-separators (for old pattern GRS) from condensate is calculated with the following formula:

$Q_{gas} = (G_f x V_k + 3.2) \times N \times n$ (m³) where:

$Q_{gas}$- losses of natural gas that occur when filters and filter-separators are separated from condensate, m³;
$G_f$- gas factor – 49.9 (the amount of gas melted in condensate and gas released together with condensate is taken into account);
$V_k$- amount of condensate released from filter, filter-separator, m³;
N – number of purges;
n – number of devices.

1.4.2. Calculation of natural gas losses occurred during the examination of gas regulators.

According to the methodology of gas regulators, examination of gas regulators is done by releasing gas into the atmosphere through "'candle". Losses of natural gas that occur during the examination of regulators are calculated with the following formula:

$$Q_{gas} = V_{piev} \frac{2893}{273.15 + t_g} \{ \frac{p_a + p_g}{K_z} - \frac{p_a}{0.998} \} ( \frac{m^3}{\text{maneuver}} )$$ where:

$Q_{gas}$- losses of gas occurred when opening or closing (maneuver) pneumatic valve, m³/maneuver;
$P_a$- atmospheric pressure, MPa ;
$P_g$- gas pressure, MPa ;
$t_g$- gas temperature, $^0$C ;
$V_{piev}$- volume of pneumatic valve actuator chamber, m³;
$K_z$- relative gas compressibility factor at gas pressure $P_g$.

1.4.4. Calculation of the amount of gas losses for gas odorization when gas pressure in the odorization equipment is decreased to the atmospheric pressure.

The amount of gas losses for gas odorization when gas pressure in the odorization equipment is decreased to the atmospheric pressure is calculated using the following formula:

$$Q_{gas} = V_{equip} \frac{2893}{273.15 + t_g} \{ \frac{p_a + p_g}{K_z} - \frac{p_a}{0.998} \}$$ m³ where:

$Q_{gas}$- gas losses for odorization, m³ ;
$V_{equip}$- volume of odorization equipment, m³ ;
$t_g$- gas temperature, $^0$C;
$P_a$- atmospheric pressure, MPa;
$P_g$- gas pressure, MPa;
$K_z$- relative gas compressibility factor at gas pressure $P_g$.

**1.5. Losses of natural gas in the automotive gas filling compressor station AGUKS.**

Losses of natural gas in the automotive gas filling compressor station AGUKS are calculated using, standards of gas losses determined after calculations.

**2. Calculation of the amount of burned natural gas.**

**2.1. Amount of burned gas during repair works, decreasing gas pressure in the Transport (Main) gas pipelines to the atmospheric pressure.**

The amount of burned gas is calculated using the following formula:

$$Q_{gas} = 2893\ V_{syst}\ \frac{1}{273.15 + t_g}\left(\frac{p_a + p_g}{K_z} - \frac{p_a}{0.998}\right)$$ ($m^3$) where:

$Q_{gas}$- amount of burned gas, $m^3$;
$V_{syst}$ - internal geometric volume of gas pipeline, $m^3$;
$t_g$ – gas temperature, $^0C$;
$P_a$ – atmospheric pressure, MPa;
$P_g$ – gas pressure, MPa;
K – relative gas compressibility factor at gas pressure $P_g$.

**2.2. Amount of burned gas during repair works, partly decreasing gas pressure in the Transport (Main) gas pipelines.**

The amount of burned gas is calculated using the following formula:

$$Q_{gas} = 2893\ V_{syst}\ \frac{1}{273.15 + t_g}\left(\frac{p_a + p_g}{K_z} - \frac{p_a + p_{atl.}}{K_{z.atl.}}\right)$$ $m^3$ where:

$Q_{gas}$– amount of burned gas, $m^3$;
$V_{syst}$ – internal geometric volume that is released from gas, $m^3$;
$P_a$ – atmospheric pressure, MPa;
$P_{atl.}$ – gas pressure in pipeline to which it was decreased, MPa;
$P_g$ – gas pressure in gas pipeline before it was decreased, MPa;
$K_z$ – relative gas compressibility factor at gas pressure $P_g$ ;
$K_{z\ atl.}$ – relative gas compressibility factor at gas pressure $P_{atl.}$;
$t_g$ – gas temperature, $^0C$.

**3. Calculation of technological losses of natural gas through gas system leakages.**

Losses of natural gas occur from gas leaks through gas system line unit shut-off device leakages. Their amount is calculated using common researches of the U.S. Gas Research Institute and Environmental Protection Agency on average gas losses through gas pipeline leakages in shut-off devices of Transport (Main) gas pipeline. Losses of natural gas because from leaks through the gas pipeline leakages are calculated using the following formula:

$$Q_{gas} = Q_{sav.} N_{sav.} + Q_{gal.} N_{gal.} \left(\frac{m^3}{a}\right)$$ where:

$Q_{gas}$– total amount of gas losses from gas leaks through leakages in Transport (Main) gas pipeline unit valves, $m^3/a$;
$Q_{sav}$– average amount of gas leaks through leakages in Transport (Main) gas pipeline unit valve, 24.55 $m^3/a$;
$N_{sav}$- amount of Transport (Main) gas pipeline unit valves (except of "candle" valves), pcs.;
$Q_{gal}$- average amount of gas leaks through leakages in Transport (Main) gas pipeline unit "candle" valve, 317.2 $m^3/a$;
$N_{gal}$- amount of Transport (Main) gas pipeline unit "candle" valves, pcs.;

**4. Calculation of technological losses of natural gas without gas releases into the atmosphere.**

It consists of the amount of natural gas necessary to fulfil pipeline with gas after the line is put into operation after repair works. Construction organisation is responsible for putting gas pipeline into operation after completion of repair works, gas necessary for implementation of this operation is sold to the organisation. Natural gas consumption is calculated using the following formula:

$$Q_{gas} = 2893 \frac{V_{syst}(p_a + p_g)}{(273.15 + t_g)K_z} (m^3)$$ where:

$Q_{gas}$– natural gas consumption necessary to fulfil gas pipeline with gas when putting it into operation after completion of construction works,$m^3$;
$V_{syst}$ - – internal geometric volume of gas pipeline, $m^3$;
$P_a$ – atmospheric pressure, MPa (0.1 MPa);
$P_g$ – gas pressure in gas pipeline after it was filled with gas, MPa;
$t_g$ – gas temperature,$^0C$ (average amount after measurements – 7 $^0C$);
$K_z$ – relative gas compressibility factor at gas pressure $P_g$.

At gas pressure $(p_a + p_g) / p_a \geq 1.84$

$$Q_{gas} = 106 \frac{(p_a + p_g)F\tau}{\rho\sqrt{273.15 + t_g}}$$ where:

$P_a$– atmospheric pressure, MPa;
$P_g$– gas pressure, MPa;
F – area of pipeline damage, $mm^2$;
τ– time of gas leak, h;
ρ– density of gas ,$kg/m^3$;
$t_g$– gas temperature, $^0C$.

At gas pressure $(p_a + p_g) / p_a < 1.84$

$$Q_{gas} = 461 \frac{(p_a + p_g)^{0.24} p_a^{0.76} F\tau}{\rho\sqrt{273.15 + t}} \sqrt{1 - \left(\frac{p_a}{p_g + p_a}\right)^{0.24}} \; m^3$$

**6. Calculation of total technological losses of natural gas in the Transport (Main) gas pipeline system.**

Total losses of natural gas with gas release into the atmosphere in the Transport (Main) gas pipeline system Qtot. are calculated by summarising the following calculation points of natural gas losses.

## METHODOLOGY FOR CALCULATION OF TECHNOLOGICAL LOSSES OF NATURAL GAS IN THE INTERNAL USER GAS SUPPLY SYSTEM

It is necessary to determine the territory where gas pipelines and equipment is located. In compliance with gas supply and usage instructions, location for gas users is determined in the place behind shut-off device in the gas pipeline actuator or other location specified in the border deed attached to gas supply agreement.

**1. Natural gas losses through gas system leakages in residential buildings with gas stoves are calculated using the following formulas:**

$Q_{gas} = q\ N\ n\ (m^3)$ where:
$Q_{gas}$ – gas losses because of leaks though internal gas system, $m^3$ ;
N – number of days, $d_n$ ;
n – amount of apartments, pcs. ;
q – amount of leaks because of leaks though internal gas system in residential buildings with stoves

**2. Additional losses of natural gas in gas fired boilers and (or) water preparation devices are calculated using the following formulas:**

$Q_{gas} = 0.7q\ N\ n\ (m^3)$ where

$Q_{gas}$ – additional losses of natural gas because of leaks in gas fired boilers and (or) hot water preparation devices, $m^3$ ;
0.7 – factor that takes into account condition of equipment;
N – number of days, $d_n$ ;
n – amount of devices, pcs.;
q – amount of leaks in gas fired boilers and (or) hot water preparation devices

## METHODOLOGY FOR CALCULATION OF TECHNOLOGICAL LOSSES OF NATURAL GAS IN THE DISTRIBUTION SYSTEM

It is necessary to determine the territory between gas transport system and distribution system for gas supplier and gas pipeline, as well as territory of equipment, gas supplier (distribution system) and user. Calculation of losses of natural gas in many cases is grounded with gas loss standards.

**<u>1. Calculation of technological losses of natural gas that occur when releasing gas into the atmosphere without burning it.</u>**

**1.1. Calculation of natural gas consumption that is necessary to purge gas pipeline with gas when putting it into operation after construction works, as well as repair works, installation or other works when gas pipeline was released from gas are done.**

When finishing gas pipeline purge, gas in the geometric volume of gas pipeline is not released into the atmosphere. Amount of natural gas released in the air consists of gas – air mixture. The amount of natural gas is calculated with the following formula:

$$Q_{gas} = 0.20\frac{Q_{syst}(p_a + p_g)T_{20}}{p_a(273.15 + t_g)}$$ ($m^3$) where:

$Q_{gas}$– consumption of natural gas necessary to purge gas pipeline with gas, $m^3$;
$Q_{sist}$– geometric volume of gas pipeline, $m^3$;
$P_a$– atmospheric pressure $kgf/m^2$;
$P_g$– gas pressure in gas pipeline, 150 $kgf/m^2$ (in distribution networks gas pipelines are purged with gas whose pressure in gas pipeline during its purge time is close to 150 $kgf/m^2$or 150 mm $H_2O$):
$T_{20}$– absolute temperature in standard conditions, K ;
$t_g$- gas temperature, $^0C$ (average gas temperature of the year = 10 $^0C$);
0.20 – factor that ensures quality of purging {1-25}.

**1.2. Calculation of gas consumption that occurs when releasing gas pipeline from gas before repair works or other works when gas pipeline must be released from gas.**

Consumption of natural gas is calculated using the following formula:

$$Q_{gas} = Q_{syst}$$ ($m^3$)

$Q_{gas}$- consumption of gas that occurs when releasing gas pipeline from gas before repair works or other works when gas pipeline must be released from gas, $m^3$ ;
$Q_{syst}$- geometric volume of gas pipeline, $m^3$ ;

**1.3. Calculation of gas consumption that occurs when decreasing gas pressure at gas regulator points (GRP).**

Consumption of natural gas is calculated using the following formula:

$$Q_{gas} = \frac{Q_{syst}(p_a + p_g)T_{20}}{p_a(273.15 + t_g)}$$ ($m^3$) where:

$Q_{gas}$- consumption of natural gas when decreasing gas pressure at gas regulator point, $m^3$;
$Q_{syst}$ – geometrical volume of gas pipeline and equipment, $m^3$;
$P_a$- atmospheric pressure, $kgf/m^2$;
$P_f$- gas pressure in gas pipeline and equipment after its decrease through gas users to pressure at GRP exit, $kgf/m^2$;
$T_{20}$- absolute temperature in standard conditions, K;
$t_g$- gas temperature, $^0C$.

**1.4. Calculation of gas that occurs when carrying out repair works of condensate collectors, water seals, gas inlet with special auxiliary device.**

Consumption of gas is calculated using the following formula:

$$Q_{gas} = qn$$ ($m^3$) where:

q – natural gas consumption standard, $m^3$/unit;
n – amount of condensate collectors, water seals, gas inlets.

**<u>2. Calculation of the amount of burned gas.</u>**

Amount of burned gas – when the gas is burned through "candle" – occurs when pressure in gas line is decreased to the atmospheric pressure. It is calculated using the following formula:

$$Q_{gas} = \frac{Q_{syst.}(p_a + p_g)T_{20}}{p_a(273.15 + t_g)} - \frac{Q_{syst.}T_{20}}{273.15 + t_g}$$ ($m^3$) where:

$Q_{gas}$- amount of burned gas, $m^3$;
$Q_{syst.}$ – geometrical volume of gas pipeline, $m^3$;
$P_a$- atmospheric pressure, $kgf/m^2$;
$P_g$- gas pressure in gas pipeline, $kgf/m^2$;
$T_{20}$- absolute temperature in standard conditions, K;
$t_g$- gas temperature, $^0C$.

**3. Calculation of technological losses of natural gas leaks through gas system.**

**3.1. Gas leaks through gas system from low-pressure yard and internal quarter gas pipelines, low-pressure distribution gas pipelines, average and high-pressure gas pipelines are calculated using the following formula:**

$$Q_{gas} = 0.5qF(\frac{m^3}{m^2 d_n})$$ where:

$Q_{gas}$- gas losses from leaks in gas system, $m^3$;
q – amount of leaks , $m^3/m^2d_n$;
F - area of internal surface of gas pipeline , $m^2$;
0.5 – factor that – using experimental data – observes;

**3.2. Gas leaks from devices at unreconstructed gas regulator points (GRP) and cabinet-type gas regulator points (CGRP) are calculated using the following formula:**

$$Q_{gas} = qN(\frac{m^3}{d_n})$$ where:

N – amount of GRP, CGRP, pcs.;
q – amount of leaks 0.288 $m^3/d_n$.

**3.3. Gas leaks of equipment at gas regulator points (GRP), cabinet-type gas regulator points (CGRP), as well as new cabinet-type gas regulator points are calculated using the following formulas:**

$$Q_{gas} = 0.5qN(\frac{m^3}{d_n})$$ where:

$Q_{gas}$– leaks from gas pipelines and equipment at reconstructed gas regulator points (GRP), cabinet-type gas regulator points (CGRP), as well as at the new cabinet-type gas regulator points, $m^3/d_n$;
q – amount of leaks 0.288 $m^3/d_n$;
N – amount of GRP, CGRP, pcs.;
0.5 – factor that observes gas leak decrease as a result of reconstruction and renovation.

**4. Calculation of losses of natural gas without gas releases into the atmosphere.**

It consists of natural gas consumption necessary to fulfill gas pipeline with gas after construction works are completed and it is being put into operation.

Consumption of natural gas is calculated using the following formula {1-25}:

(15) $$Q_{gas} = \frac{Q_{syst.}(p_a + p_g)T_{20}}{p_a(273.15 + t_g)}$$ ($m^3$) where:

$Q_{gas}$- natural gas consumption to fulfill gas pipeline with gas after construction works are completed and it is being put into operation, $m^3$;
$Q_{syst.}$ – internal geometrical volume of gas pipeline, $m^3$;

$P_a$- atmospheric pressure, kgf/m$^2$;
$P_g$- gas pressure in gas pipeline, kgf/m$^2$;
$T_{20}$- absolute temperature in standard conditions, K;
$t_g$- gas temperature, $^0$C.

**5. Calculation of emergency outflows.**

Emergency outflows are unplanned losses of natural gas that occur from significant damages of gas pipelines and equipment. These unplanned losses of natural gas can be released into the atmosphere by burning, as well as not burning the gas. If area of damage is smaller than cross-section area of pipeline, then natural gas losses, are calculated using the following formulas:

$$Q_{gas} = 106 \frac{(p_a + p_g)F\tau}{\rho\sqrt{273.15 + t_g}} \text{ m}^3 \text{ at } (p_a + p_g)/p_a \geq 1.84$$

where:

$P_a$– atmospheric pressure, MPa ;
$P_g$– gas pressure, MPa;
F – area of damaged pipeline, mm$^2$;
τ– gas leak time, h;
ρ– density of gas,kg/cm$^3$;
$t_g$– gas temperature, $^0$C.

$$Q_{gas} = 461 \frac{(p_a + p_g)^{0.24} p_a^{\ 0.76} F\tau}{\rho\sqrt{273.15 + t}} \sqrt{1 - \frac{p_a}{(p_g + p_u)^{0.24}}} \ (m^3) \text{ at } (p_a + p_g)/p_a < 1.84$$

If area of damaged pipeline is comparable with cross-section area of pipeline, then gas pressure in pipeline decreases and becomes a multiple parameter function.

## A.3.5 Transport

### Distribution of road transport fleet by subsectors and layers, year 2014

| Subsector | Technology | population | mileage |
|---|---|---|---|
| Passenger Cars | | | |
| Gasoline <1,4 l | ECE 15/03 | 400 | 2700 |
| Gasoline <1,4 l | ECE 15/04 | 934 | 3600 |
| Gasoline <1,4 l | PC Euro 1 - 91/441/EEC | 5023 | 5500 |
| Gasoline <1,4 l | PC Euro 2 - 94/12/EEC | 7189 | 9000 |
| Gasoline <1,4 l | PC Euro 3 - 98/69/EC Stage2000 | 6934 | 12000 |
| Gasoline <1,4 l | PC Euro 4 - 98/69/EC Stage2005 | 10715 | 14000 |
| Gasoline <1,4 l | PC Euro 5 - EC 715/2007 | 6031 | 19000 |
| Gasoline <1,4 l | PC Euro 6 - EC 715/2007 | 164 | 19000 |
| Gasoline 1,4 - 2,0 l | ECE 15/03 | 4552 | 2430 |
| Gasoline 1,4 - 2,0 l | ECE 15/04 | 10621 | 3600 |
| Gasoline 1,4 - 2,0 l | PC Euro 1 - 91/441/EEC | 50263 | 7150 |
| Gasoline 1,4 - 2,0 l | PC Euro 2 - 94/12/EEC | 41820 | 12000 |
| Gasoline 1,4 - 2,0 l | PC Euro 3 - 98/69/EC Stage2000 | 23128 | 15068 |
| Gasoline 1,4 - 2,0 l | PC Euro 4 - 98/69/EC Stage2005 | 27028 | 17000 |
| Gasoline 1,4 - 2,0 l | PC Euro 5 - EC 715/2007 | 9656 | 20000 |
| Gasoline 1,4 - 2,0 l | PC Euro 6 - EC 715/2007 | 279 | 22000 |
| Gasoline >2,0 l | ECE 15/03 | 690 | 2700 |
| Gasoline >2,0 l | ECE 15/04 | 1610 | 4228 |
| Gasoline >2,0 l | PC Euro 1 - 91/441/EEC | 7074 | 9902 |
| Gasoline >2,0 l | PC Euro 2 - 94/12/EEC | 9149 | 14000 |
| Gasoline >2,0 l | PC Euro 3 - 98/69/EC Stage2000 | 8975 | 15000 |
| Gasoline >2,0 l | PC Euro 4 - 98/69/EC Stage2005 | 7886 | 19000 |
| Gasoline >2,0 l | PC Euro 5 - EC 715/2007 | 2178 | 21000 |
| Gasoline >2,0 l | PC Euro 6 - EC 715/2007 | 160 | 21500 |
| Diesel <2,0 l | Conventional | 5262 | 10000 |
| Diesel <2,0 l | PC Euro 1 - 91/441/EEC | 19961 | 11000 |
| Diesel <2,0 l | PC Euro 2 - 94/12/EEC | 35457 | 12000 |
| Diesel <2,0 l | PC Euro 3 - 98/69/EC Stage2000 | 53902 | 14000 |
| Diesel <2,0 l | PC Euro 4 - 98/69/EC Stage2005 | 33920 | 16545 |
| Diesel <2,0 l | PC Euro 5 - EC 715/2007 | 13002 | 21586 |
| Diesel <2,0 l | PC Euro 6 - EC 715/2007 | 614 | 22000 |
| Diesel >2,0 l | Conventional | 3035 | 11872 |
| Diesel >2,0 l | PC Euro 1 - 91/441/EEC | 14486 | 13000 |
| Diesel >2,0 l | PC Euro 2 - 94/12/EEC | 21856 | 14000 |
| Diesel >2,0 l | PC Euro 3 - 98/69/EC Stage2000 | 46364 | 15000 |
| Diesel >2,0 l | PC Euro 4 - 98/69/EC Stage2005 | 22095 | 18000 |
| Diesel >2,0 l | PC Euro 5 - EC 715/2007 | 5684 | 23000 |
| Diesel >2,0 l | PC Euro 6 - EC 715/2007 | 507 | 22000 |
| LPG | Conventional | 3110 | 15000 |
| LPG | PC Euro 1 - 91/441/EEC | 10994 | 19000 |

| Subsector | Technology | population | mileage |
|---|---|---|---|
| LPG | PC Euro 2 - 94/12/EEC | 13692 | 20000 |
| LPG | PC Euro 3 - 98/69/EC Stage2000 | 10127 | 21000 |
| LPG | PC Euro 4 - 98/69/EC Stage2005 | 6221 | 22040 |
| LPG | PC Euro 5 - EC 715/2007 | 1484 | 23690 |
| LPG | PC Euro 6 - EC 715/2007 | 6 | 24620 |
| Light Duty Vehicles | | | |
| LPG | Conventional | 255 | 30369 |
| LPG | LD Euro 1 - 93/59/EEC | 171 | 30369 |
| LPG | LD Euro 2 - 96/69/EEC | 154 | 31000 |
| LPG | LD Euro 3 - 98/69/EC Stage2000 | 117 | 33000 |
| LPG | LD Euro 4 - 98/69/EC Stage2005 | 233 | 43074 |
| LPG | LD Euro 5 - 2008 Standards | 139 | 47984 |
| Gasoline <3,5t | Conventional | 266 | 17000 |
| Gasoline <3,5t | LD Euro 1 - 93/59/EEC | 201 | 18000 |
| Gasoline <3,5t | LD Euro 2 - 96/69/EEC | 404 | 19000 |
| Gasoline <3,5t | LD Euro 3 - 98/69/EC Stage2000 | 303 | 21500 |
| Gasoline <3,5t | LD Euro 4 - 98/69/EC Stage2005 | 593 | 28000 |
| Gasoline <3,5t | LD Euro 5 - 2008 Standards | 308 | 31000 |
| Gasoline <3,5t | LD Euro 6 | 5 | 31000 |
| Diesel <3,5 t | Conventional | 2636 | 25000 |
| Diesel <3,5 t | LD Euro 1 - 93/59/EEC | 3245 | 25000 |
| Diesel <3,5 t | LD Euro 2 - 96/69/EEC | 7540 | 26000 |
| Diesel <3,5 t | LD Euro 3 - 98/69/EC Stage2000 | 8297 | 27800 |
| Diesel <3,5 t | LD Euro 4 - 98/69/EC Stage2005 | 11203 | 32460 |
| Diesel <3,5 t | LD Euro 5 - 2008 Standards | 7203 | 39000 |
| Diesel <3,5 t | LD Euro 6 | 21 | 39000 |
| Heavy Duty Trucks | | | |
| LPG | Conventional | 340 | 24000 |
| LPG | HD Euro I - 91/542/EEC Stage I | 120 | 24400 |
| LPG | HD Euro II - 91/542/EEC Stage II | 62 | 26000 |
| Gasoline >3,5 t | Conventional | 769 | 18000 |
| Gasoline >3,5 t | HD Euro I - 91/542/EEC Stage I | 293 | 18500 |
| Gasoline >3,5 t | HD Euro II - 91/542/EEC Stage II | 72 | 18644 |
| Gasoline >3,5 t | HD Euro III - 2000 Standards | 13 | 25057 |
| Rigid <=7,5 t | Conventional | 873 | 20400 |
| Rigid <=7,5 t | HD Euro I - 91/542/EEC Stage I | 526 | 20411 |
| Rigid <=7,5 t | HD Euro II - 91/542/EEC Stage II | 630 | 20411 |
| Rigid <=7,5 t | HD Euro III - 2000 Standards | 566 | 27431 |
| Rigid <=7,5 t | HD Euro IV - 2005 Standards | 443 | 40071 |
| Rigid <=7,5 t | HD Euro V - 2008 Standards | 182 | 42079 |
| Rigid <=7,5 t | HD Euro VI | 11 | 42079 |
| Rigid 7,5 - 12 t | Conventional | 439 | 20600 |
| Rigid 7,5 - 12 t | HD Euro I - 91/542/EEC Stage I | 273 | 20603 |
| Rigid 7,5 - 12 t | HD Euro II - 91/542/EEC Stage II | 310 | 20603 |

| Subsector | Technology | population | mileage |
|---|---|---|---|
| Rigid 7,5 - 12 t | HD Euro III - 2000 Standards | 342 | 28929 |
| Rigid 7,5 - 12 t | HD Euro IV - 2005 Standards | 247 | 38291 |
| Rigid 7,5 - 12 t | HD Euro V - 2008 Standards | 88 | 36565 |
| Rigid 7,5 - 12 t | HD Euro VI | 5 | 36565 |
| Rigid 12 - 14 t | Conventional | 135 | 20700 |
| Rigid 12 - 14 t | HD Euro I - 91/542/EEC Stage I | 87 | 20702 |
| Rigid 12 - 14 t | HD Euro II - 91/542/EEC Stage II | 72 | 20702 |
| Rigid 12 - 14 t | HD Euro III - 2000 Standards | 31 | 23111 |
| Rigid 12 - 14 t | HD Euro IV - 2005 Standards | 41 | 29129 |
| Rigid 12 - 14 t | HD Euro V - 2008 Standards | 16 | 31534 |
| Rigid 12 - 14 t | HD Euro VI | 2 | 31534 |
| Rigid 14 - 20 t | Conventional | 795 | 29000 |
| Rigid 14 - 20 t | HD Euro I - 91/542/EEC Stage I | 588 | 29000 |
| Rigid 14 - 20 t | HD Euro II - 91/542/EEC Stage II | 1337 | 29000 |
| Rigid 14 - 20 t | HD Euro III - 2000 Standards | 1887 | 36000 |
| Rigid 14 - 20 t | HD Euro IV - 2005 Standards | 1380 | 52000 |
| Rigid 14 - 20 t | HD Euro V - 2008 Standards | 3364 | 57000 |
| Rigid 14 - 20 t | HD Euro VI | 239 | 57000 |
| Rigid 20 - 26 t | Conventional | 266 | 38000 |
| Rigid 20 - 26 t | HD Euro I - 91/542/EEC Stage I | 295 | 38000 |
| Rigid 20 - 26 t | HD Euro II - 91/542/EEC Stage II | 303 | 38000 |
| Rigid 20 - 26 t | HD Euro III - 2000 Standards | 419 | 53000 |
| Rigid 20 - 26 t | HD Euro IV - 2005 Standards | 380 | 74000 |
| Rigid 20 - 26 t | HD Euro V - 2008 Standards | 629 | 78000 |
| Rigid 20 - 26 t | HD Euro VI | 67 | 78000 |
| Rigid 26 - 28 t | Conventional | 31 | 38000 |
| Rigid 26 - 28 t | HD Euro I - 91/542/EEC Stage I | 45 | 38000 |
| Rigid 26 - 28 t | HD Euro II - 91/542/EEC Stage II | 45 | 38000 |
| Rigid 26 - 28 t | HD Euro III - 2000 Standards | 79 | 53000 |
| Rigid 26 - 28 t | HD Euro IV - 2005 Standards | 56 | 74000 |
| Rigid 26 - 28 t | HD Euro V - 2008 Standards | 95 | 78000 |
| Rigid 26 - 28 t | HD Euro VI | 20 | 78000 |
| Rigid 28 - 32 t | Conventional | 18 | 38400 |
| Rigid 28 - 32 t | HD Euro I - 91/542/EEC Stage I | 33 | 38400 |
| Rigid 28 - 32 t | HD Euro II - 91/542/EEC Stage II | 50 | 38400 |
| Rigid 28 - 32 t | HD Euro III - 2000 Standards | 67 | 53000 |
| Rigid 28 - 32 t | HD Euro IV - 2005 Standards | 63 | 74000 |
| Rigid 28 - 32 t | HD Euro V - 2008 Standards | 94 | 78000 |
| Rigid 28 - 32 t | HD Euro VI | 12 | 78000 |
| Rigid >32 t | Conventional | 22 | 38400 |
| Rigid >32 t | HD Euro I - 91/542/EEC Stage I | 22 | 38400 |
| Rigid >32 t | HD Euro II - 91/542/EEC Stage II | 43 | 38400 |
| Rigid >32 t | HD Euro III - 2000 Standards | 37 | 53000 |
| Rigid >32 t | HD Euro IV - 2005 Standards | 98 | 74000 |

| Subsector | Technology | population | mileage |
|---|---|---|---|
| Rigid >32 t | HD Euro V - 2008 Standards | 37 | 78000 |
| Rigid >32 t | HD Euro VI | 2 | 78000 |
| Articulated 14 - 20 t | Conventional | 340 | 29200 |
| Articulated 14 - 20 t | HD Euro I - 91/542/EEC Stage I | 252 | 29500 |
| Articulated 14 - 20 t | HD Euro II - 91/542/EEC Stage II | 573 | 29550 |
| Articulated 14 - 20 t | HD Euro III - 2000 Standards | 808 | 38000 |
| Articulated 14 - 20 t | HD Euro IV - 2005 Standards | 591 | 52000 |
| Articulated 14 - 20 t | HD Euro V - 2008 Standards | 1441 | 57000 |
| Articulated 14 - 20 t | HD Euro VI | 103 | 57000 |
| Articulated 20 - 28 t | Conventional | 335 | 38000 |
| Articulated 20 - 28 t | HD Euro I - 91/542/EEC Stage I | 383 | 38000 |
| Articulated 20 - 28 t | HD Euro II - 91/542/EEC Stage II | 392 | 38000 |
| Articulated 20 - 28 t | HD Euro III - 2000 Standards | 562 | 52000 |
| Articulated 20 - 28 t | HD Euro IV - 2005 Standards | 492 | 74000 |
| Articulated 20 - 28 t | HD Euro V - 2008 Standards | 816 | 78000 |
| Articulated 20 - 28 t | HD Euro VI | 97 | 78000 |
| Articulated 28 - 34 t | Conventional | 46 | 38000 |
| Articulated 28 - 34 t | HD Euro I - 91/542/EEC Stage I | 62 | 38000 |
| Articulated 28 - 34 t | HD Euro II - 91/542/EEC Stage II | 105 | 38000 |
| Articulated 28 - 34 t | HD Euro III - 2000 Standards | 117 | 52000 |
| Articulated 28 - 34 t | HD Euro IV - 2005 Standards | 182 | 74000 |
| Articulated 28 - 34 t | HD Euro V - 2008 Standards | 149 | 78000 |
| Articulated 28 - 34 t | HD Euro VI | 15 | 78000 |
| Buses | | | |
| Urban Buses | Conventional | 7 | 29840 |
| Urban Buses | HD Euro I - 91/542/EEC Stage I | 2 | 29840 |
| Urban Buses | HD Euro II - 91/542/EEC Stage II | 11 | 29840 |
| Urban Buses Midi <=15 t | Conventional | 245 | 32567 |
| Urban Buses Midi <=15 t | HD Euro I - 91/542/EEC Stage I | 199 | 32567 |
| Urban Buses Midi <=15 t | HD Euro II - 91/542/EEC Stage II | 260 | 32567 |
| Urban Buses Midi <=15 t | HD Euro III - 2000 Standards | 308 | 43891 |
| Urban Buses Midi <=15 t | HD Euro IV - 2005 Standards | 354 | 56098 |
| Urban Buses Midi <=15 t | HD Euro V - 2008 Standards | 627 | 52520 |
| Urban Buses Midi <=15 t | HD Euro VI | 47 | 52520 |
| Coaches Standard <=18 t | Conventional | 229 | 47805 |
| Coaches Standard <=18 t | HD Euro I - 91/542/EEC Stage I | 199 | 47805 |
| Coaches Standard <=18 t | HD Euro II - 91/542/EEC Stage II | 180 | 47805 |
| Coaches Standard <=18 t | HD Euro III - 2000 Standards | 168 | 59027 |
| Coaches Standard <=18 t | HD Euro IV - 2005 Standards | 115 | 62020 |
| Coaches Standard <=18 t | HD Euro V - 2008 Standards | 129 | 69080 |
| Coaches Standard <=18 t | HD Euro VI | 1 | 69080 |
| Coaches Articulated >18 t | Conventional | 55 | 47805 |
| Coaches Articulated >18 t | HD Euro I - 91/542/EEC Stage I | 126 | 47805 |
| Coaches Articulated >18 t | HD Euro II - 91/542/EEC Stage II | 183 | 47805 |

| Subsector | Technology | population | mileage |
|---|---|---|---|
| Coaches Articulated >18 t | HD Euro III - 2000 Standards | 251 | 59027 |
| Coaches Articulated >18 t | HD Euro IV - 2005 Standards | 76 | 62020 |
| Coaches Articulated >18 t | HD Euro V - 2008 Standards | 19 | 69080 |
| Coaches Articulated >18 t | HD Euro VI | 48 | 69080 |
| Mopeds | | | |
| <50 cm$^3$ | Conventional | 132 | 1000 |
| <50 cm$^3$ | Mop - Euro I | 1456 | 1150 |
| <50 cm$^3$ | Mop - Euro II | 11648 | 1150 |
| Motorcycles | | | |
| 2-stroke >50 cm$^3$ | Conventional | 1252 | 1100 |
| 2-stroke >50 cm$^3$ | Mot - Euro I | 1879 | 1600 |
| 2-stroke >50 cm$^3$ | Mot - Euro II | 835 | 1600 |
| 2-stroke >50 cm$^3$ | Mot - Euro III | 1253 | 1600 |
| 4-stroke <250 cm$^3$ | Mot - Euro III | 702 | 400 |
| 4-stroke 250 - 750 cm$^3$ | Conventional | 1168 | 1400 |
| 4-stroke 250 - 750 cm$^3$ | Mot - Euro I | 1752 | 2000 |
| 4-stroke 250 - 750 cm$^3$ | Mot - Euro II | 1168 | 2000 |
| 4-stroke 250 - 750 cm$^3$ | Mot - Euro III | 1752 | 2400 |
| 4-stroke >750 cm$^3$ | Conventional | 730 | 1800 |
| 4-stroke >750 cm$^3$ | Mot - Euro I | 1094 | 2000 |
| 4-stroke >750 cm$^3$ | Mot - Euro II | 730 | 2000 |
| 4-stroke >750 cm$^3$ | Mot - Euro III | 1094 | 2400 |

### A.3.6 Industrial Processes and Product Use Sector

**Methodological description for emission estimation from bricks and tiles production**

There is only one tiles production plant in Latvia and $CO_2$ emissions from use of clay in tile production process in 1995-2014 are reported in 2.A.4 sector. The tiles production plant is participant of EU ETS therefore the data from plant's annual GHG reports is available for inventory.

**Table 1 $CO_2$ emissions from tile production (kt)**

| | $CO_2$ emissions (kt) |
|---|---|
| **1990** | NO |
| **1995** | 0.163 |
| **2000** | 0.208 |
| **2005** | 0.135 |
| **2006** | 0.140 |
| **2007** | 0.179 |
| **2008** | 0.042 |
| **2009** | 0.229 |
| **2010** | 0.200 |
| **2011** | 0.279 |
| **2012** | 0.483 |
| **2013** | 0.535 |
| **2014** | 0.524 |

Default methodology was used to estimate emissions when activity data is multiplied with emission factor but the $CO_2$ emission factor – 0.08794 (t $CO_2$/t dry clay), used to estimate emissions from clay use in tiles production are taken from Monitoring Reporting Guidelines (MRG[262]).

Amount of used clay in tiles production is taken from only tiles production plant in Latvia (Table 2).

**Table 2 Activity data for tiles production (kt)**

| | Use of clay in tiles production (kt) |
|---|---|
| **1990** | NO |
| **1995** | 2.034 |
| **2000** | 2.594 |
| **2005** | 1.685 |
| **2006** | 1.748 |
| **2007** | 2.242 |

[262] *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:LV:PDF, page 80*

| | **Use of clay in tiles production (kt)** |
|---|---|
| **2008** | 0.525 |
| **2009** | 2.861 |
| **2010** | 2.497 |
| **2011** | 3.484 |
| **2012** | 6.033 |
| **2013** | 6.684 |
| **2014** | 6.556 |

Estimation of $CO_2$ emission factor in bricks production plants is rather complicated and based on physical and chemical characteristics of raw materials and type of activity data for estimations of emissions.

$CO_2$ emission estimation for 1990-1992

For years 1990-1992 no plant specific data is available from bricks production plants therefore $CO_2$ emission estimation for these 3 years is done based on final produced bricks amount if average weight of one brick is known.

According to statistical information average weight of one brick is 3.9kg and according to plant data average produced bricks / used clay ratio is 1.25.

If final amount of produced bricks is known, it is possible to determine approximate clay consumption (Table 3). In $CO_2$ emission estimation emission factor 0.047 $tCO_2$/t used clay is used.

**Table 3 Data and assumptions used for $CO_2$ emission estimation for 1990-1992**

| | **1990** | **1991** | **1992** |
|---|---|---|---|
| produced bricks (thousand pieces) | 471800 | 546423 | 259918 |
| average weight of one brick (kg) | 3.9 | 3.9 | 3.9 |
| produced bricks (tonnes) | 1840020 | 2131049.7 | 1013680.2 |
| average produced bricks / used clay ratio | 1.25 | 1.25 | 1.25 |
| used clay (kt) | **1472.016** | **1704.84** | **810.9442** |
| $CO_2$ emission factor of used clay $tCO_2$/t used clay | 0.047 | 0.047 | 0.047 |
| $CO_2$ emissions (kt) | 69.1848 | 80.1275 | 38.1144 |

$CO_2$ emissions are estimated differently in Latvia's five bricks production plants as well as estimation methodology differs because it was possible to use higher tier of emission estimation in latest years due to availability of necessary activity data and laboratory measurements of used raw materials.

**1st bricks production plant**

During the revision of 1st bricks production plant's application to GHG permit, annual GHG reports for 2005-2009 it was stated that the plant has changed used $CO_2$ emission estimation methodology 3 times:

1. $CO_2$ emission for time period 1993-2004 was estimated by using used clay as an activity data and $CO_2$ emission factor for used clay – 0.047 t $CO_2$/t used clay. The particular emission factor is determined for total used clay data when clay characterizations are not known. $CO_2$ emissions are determined by ignition loses of clay: in 1000° C – 4.7% of instant $CO_2$ is emitted).
2. For 2005-2007 the plant is using calculation method B – alkali earth oxides, from the MRG when calculation is based on the content of the CaO, MgO and other (earth) alkali.
3. For years 2008-2012 plant is using the calculation method "A" – carbon input, from the MRG when calculation is based on the carbon input on each of the relevant raw materials. Tier 1 emission factors from the MRG corresponding particular method are used when conservative value of 0.2 tonnes $CaCO_3$ (0.08794 tonnes of $CO_2$) per tonne of dry clay is applied for the calculation of the emission factor instead of results of analyses.

First bricks production plant's used methodology for $CO_2$ emission estimation in whole time series is inconsistent as methodology is changed several times and for 2008 estimation methodology is again switched from Tier2 to Tier1 and default average $CO_2$ emission factor is used.

*Methods*

The $CO_2$ emissions in whole time period was calculated by using calculation method B – alkali earth oxides, from the MRG when calculation is based on the content of the CaO, MgO and other (earth) alkali[263].

According to bricks production plant's reported information the following equation to estimate $CO_2$ emissions was used:

$$CO_2 = \sum\left(\left(AD_{raw} \times AD_{CaO,MgO}\right) \times EF \times CF\right)$$

*where:*
*$CO_2$ – total $CO_2$ emissions from bricks production (kt)*
*$AD_{raw}$ – activity data of used raw materials – clay (kt)*
*$AD_{CaO,MgO}$ – CaO and MgO content in used raw materials (%)*
*EF – $CO_2$ emission factor of CaO and MgO (kt/kt)*
*CF – conversion factor*

*Emission factors*

$CO_2$ emission factors for CaO and MgO – 0.785 and 1.092 for tonne $CO_2$ per tonne of oxide respectively, were taken from MRG[264] (Table 4).

*Activity data*

[263] *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 80)*
[264] *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 81)*

As MgO and CaO content data was not available for years 1993-2004 therefore the data reported in bricks production plant's GHG report for 2005 was used: MgO content – 4.9%, CaO content – 11.6%.

As for years 2008-2009 different emission estimation methodology is used and MgO and CaO data is not available content data of 2006-2007 was used also to estimate emissions for 2008-2012: MgO content – 2.9%, CaO content – 10.26%.

**Table 4 Data and assumptions used for $CO_2$ emission estimation from 1st bricks production plant**

| | Use of clay (kt) | MgO content (%) | CaO content (%) | MgO amount (kt) | CaO amount (kt | MgO $CO_2$ EF ($tCO_2$/t oxide) | CaO $CO_2$ EF ($tCO_2$/t oxide) | $CO_2$ emissions (kt) | Average $CO_2$ EF ($tCO_2$/t oxides) |
|---|---|---|---|---|---|---|---|---|---|
| **1990** | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **1995** | 2.700 | 4.90% | 11.60% | 0.132 | 0.313 | 1.092 | 0.785 | 0.390 | 0.876 |
| **2000** | 4.800 | 4.90% | 11.60% | 0.235 | 0.557 | 1.092 | 0.785 | 0.694 | 0.876 |
| **2005** | 5.257 | 4.90% | 11.60% | 0.258 | 0.610 | 1.092 | 0.785 | 0.760 | 0.876 |
| **2006** | 6.245 | 2.90% | 10.26% | 0.181 | 0.641 | 1.092 | 0.785 | 0.701 | 0.853 |
| **2007** | 7.745 | 2.90% | 10.26% | 0.225 | 0.795 | 1.092 | 0.785 | 0.869 | 0.853 |
| **2008** | 3.880 | 2.90% | 10.26% | 0.113 | 0.398 | 1.092 | 0.785 | 0.435 | 0.853 |
| **2009** | 2.268 | 2.90% | 10.26% | 0.066 | 0.233 | 1.092 | 0.785 | 0.254 | 0.853 |
| **2010** | 1.922 | 2.90% | 10.26% | 0.056 | 0.197 | 1.092 | 0.785 | 0.216 | 0.853 |
| **2011** | 1.698 | 2.90% | 10.26% | 0.049 | 0.174 | 1.092 | 0.785 | 0.191 | 0.853 |
| **2012** | 1.670 | 2.90% | 10.26% | 0.048 | 0.171 | 1.092 | 0.785 | 0.187 | 0.853 |

In 2013 1st bricks production plant is not operating anymore.

**2nd bricks production plant**

$CO_2$ emissions for 2nd bricks production plant is recalculated only for year 2008 in comparison with plant's annual GHG report. For 1999-2008 the plant is using the same emission estimation methodology but for year 2008 average default emission factor from MRG is used. As this emission factor is Tier1 emission factor but for previous years Tier2 emission factors are used it was decided to recalculate emissions for 2008.

The plant was closed at the end of 2008 and wasn't operated in 2009 due to company's reorganization when production plant using old obsolete installations were closed and all production was transferred to other modern production facilities.

*Methods*

Calculation method A – carbon input, from the MRG[265] is used in plant's emission estimation for its application for GHG permit as well for reporting of annual $CO_2$ emission:

[265] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 79)

$$CO_2 = \left(AD_{raw} \times AD_{CaCO_3} \times EF_{CaCO_3}\right) + \left(AD_{raw} \times AD_{MgCO_3} \times EF_{MgCO_3}\right)$$

*where:*
*$CO_2$ – $CO_2$ emissions from 2nd bricks production plant (kt)*
*$AD_{raw}$ – activity data of used clay (kt)*
*$AD_{CaCO3}$ – $CaCO_3$ content in used clay (%)*
*$EF_{CaCO3}$ – $CaCO_3$ emission factor (kt/kt)*
*$AD_{MgCO3}$ – $MgCO_3$ content in used clay (%)*
*$EF_{MgCO3}$ – $MgCO_3$ emission factor (kt/kt)*

*Emission factors*

Default $CO_2$ emission factors from the MRG for the $CaCO_3$ and $MgCO_3$ are used. $CO_2$ emission factor for $CaCO_3$ is 0.44 $tCO_2$/t $CaCO_3$ and $CO_2$ emission factor for $MgCO_3$ is 0.522 $tCO_2$/t $MgCO_3$.

*Activity data*

The content of $CaCO_3$ and $MgCO_3$ are determined in plant laboratories or stated in mineral deposits passport.

Activity data carbonate is $CaCO_3$, $MgCO_3$ or other alkali earth or alkali carbonates amount that is used during the reporting period input (clay). Carbonate mass is estimated using clay consumption amount and results of clay content measurement with maximal allowable process uncertainty of ± 2.5% (Table 5).

**Table 5 Data and assumptions used for $CO_2$ emission estimation from 2nd bricks production plant**

| | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| Use of clay (kt) | NO | NO | 16.37 | 22.983 | 28.559 | 37.203 | 13.975 |
| $MgCO_3$ content (%) | NO | NO | 5.00% | 10.98% | 9.56% | 9.52% | 9.50% |
| $CaCO_3$ content (%) | NO | NO | 9.00% | 13.06% | 13.15% | 13.10% | 13.10% |
| $MgCO_3$ amount (kt) | NO | NO | 0.819 | 2.523 | 2.729 | 3.542 | 1.328 |
| $CaCO_3$ amount (kt) | NO | NO | 1.473 | 3.002 | 3.756 | 4.874 | 1.831 |
| $MgCO_3$ $CO_2$ EF ($tCO_2$/t oxide) | NO | NO | 0.522 | 0.522 | 0.522 | 0.522 | 0.522 |
| $CaCO_3$ $CO_2$ EF ($tCO_2$/t oxide) | NO | NO | 0.440 | 0.440 | 0.440 | 0.440 | 0.440 |
| $CO_2$ emissions (kt) | NO | NO | 1.076 | 2.638 | 3.077 | 3.993 | 1.500 |
| Average $CO_2$ EF ($tCO_2$/t oxides) | NO | NO | 0.469 | 0.477 | 0.475 | 0.475 | 0.474 |

As it was mentioned the plant wasn't operated in 2009 and it is approved that most likely the plant will not be reopened again.

**3rd bricks production plant**

$CO_2$ emission that 3rd plant is estimated for 1998-2004 in its application for GHG permit during the implementation of ETS in Latvia by using the methodology that is not in line with 2006 IPCC Guidelines. Still in the application the plant had reported the MgO and CaO content data in used dry clay therefore the emissions were recalculated using the available activity data.

The $CO_2$ emissions from particular bricks production plant was recalculated for 2008 and 2009 as the methodology use was stated as consistent only in 1998-2007 although the methodology was changed in 2005. The methodology was changed from one approach – alkali earth oxides, to other approach – carbon input because the carbon input laboratory measurement data is available since 2005. As both methodologies are appropriate and both are assumed as Tier2 therefore the methodology change was considered as acceptable.

Still for years 2008-2009 lower tier emission factor from MRG[266] – a conservative value of 0.2 tonnes $CaCO_3$ (corresponding to 0.08794 tonnes of $CO_2$) per tonne of dry clay, was used to estimate $CO_2$ emissions. The plant indicates that the lower tier use is acceptable within EU ETS as the plant is low emission producer.

*Methods*

For 1998-2004 the plant is using calculation method B – alkali earth oxides, from the MRG when calculation is based on the content of the CaO, MgO and other (earth) alkali.

According to bricks production plant's reported information the following equation to estimate $CO_2$ emissions was used:

$$CO_2 = \sum\left(\left(AD_{raw} \times AD_{CaO,MgO}\right) \times EF \times CF\right)$$

*where:*
*$CO_2$ – total $CO_2$ emissions from bricks production (kt)*
*$AD_{raw}$ – activity data of used raw materials – clay (kt)*
*$AD_{CaO,MgO}$ – CaO and MgO content in used raw materials (%)*
*EF – $CO_2$ emission factor of CaO and MgO (kt/kt)*
*CF – conversion factor*

The plant for time period 2005-2007 is using the calculation method A – carbon input, from the MRG when calculation is based on the carbon input on each of the relevant raw materials. As it was mentioned above the plant in using different methodology again for 2008-2009 therefore the data was recalculated using the emission estimation method as for 2005-2007. Following equation from MRG is used to estimate emissions for 2005-2012:

$$CO_2 = \left(AD_{raw} \times AD_{CaCO_3} \times EF_{CaCO_3}\right) + \left(AD_{raw} \times AD_{MgCO_3} \times EF_{MgCO_3}\right)$$

*where:*
*$CO_2$ – $CO_2$ emissions from 3rd bricks production plant (kt)*
*$AD_{raw}$ – activity data of used clay (kt)*
*$AD_{CaCO3}$ – $CaCO_3$ content in used clay (%)*
*$EF_{CaCO3}$ – $CaCO_3$ emission factor (kt/kt)*
*$AD_{MgCO3}$ – $MgCO_3$ content in used clay (%)*
*$EF_{MgCO3}$ – $MgCO_3$ emission factor (kt/kt)*

*Emission factors*

$CO_2$ emission factors for CaO and MgO – 0.785 and 1.092 for tonne $CO_2$ per tonne of oxide respectively, were taken from MRG[267] (Table 4.2.17).

$CO_2$ emission factors for $CaCO_3$ and $MgCO_3$ – 0.44 and 0.522 for tonne $CO_2$ per tonne of carbonates respectively, were taken from MRG[268] to recalculate the emissions (Table 6, Table 7).

*Activity data*

[266] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF *(page 80)*
[267] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF *(page 81)*
[268] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF *(page 79)*

For 1998-2004 emission estimation MgO and CaO content is used. According to mineral passport of State Geology Service's quarry "Progress" alkali earth oxides – MgO and CaO, contents are 8.03% and 3.02% respectively.

For years 2005-2007 emission estimation the contents of $CaCO_3$ and $MgCO_3$ are determined in plant laboratories or stated in mineral deposits passport and are 12.79% and 10.75% respectively. As for year 2008-2009 the carbonates input percentage amount is not known the data of 2005-2007 was used (Table 6, Table 7).

According to production plant's application for GHG permit and annual GHG reports activity data of used raw materials is estimated using following equation:

$$AD_{raw} = AD_{clay} \times (1 - M)$$

*where:*
*$AD_{raw}$ – activity data of used raw materials – dray clay (kt)*
*$AD_{clay}$ – amount of used clay (kt)*
*M – moisture content of clay in bricks pressing process (%)*

For year 2005-2014 the activity data was estimated by using following equation from bricks production plant's GHG report:

$$AD_{raw} = \sum (AD_{bulk} \times M_{av})$$

*where:*
*$AD_{raw}$ – activity data of used raw materials – clay (kt)*
*$AD_{bulk}$ – amount of dried bulk materials (pieces)*
*$M_{av}$ – average mass with 0% moisture content (kt)*

The activity data was estimated by plant randomly taking 10 examples of production from drying tunnels dried after that till 0% moisture content and weighted. After that average mass of production is estimated. Therefore for year 2005-2014 the used clay is reported already with 0% moisture content.

The used raw materials – used clay, were estimated by taking into account the moisture content of the clay.

**Table 6 Data and assumptions used for $CO_2$ emission estimation from 3rd bricks production plant**

| | **1990** | **1995** | **2000** |
|---|---|---|---|
| use of clay (kt) | NO | NO | 10.25 |
| moisture content (%) | NO | NO | 17.00% |
| used raw materials - dry clay (kt) | NO | NO | 8.51 |
| MgO content (%) | NO | NO | 8.03% |
| CaO content (%) | NO | NO | 3.02% |
| MgO amount (kt) | NO | NO | 0.683 |
| CaO amount (kt) | NO | NO | 0.257 |
| MgO $CO_2$ EF ($tCO_2$/t oxide) | NO | NO | 1.092 |
| CaO $CO_2$ EF ($tCO_2$/t oxide) | NO | NO | 0.785 |
| **$CO_2$ emissions (kt)** | **NO** | **NO** | **0.95** |
| Average $CO_2$ EF ($tCO_2$/t oxides) | NO | NO | 1.008 |

**Table 7 Data and assumptions used for $CO_2$ emission estimation from 3rd bricks production plant (continuation)**

| | use of clay (kt) | $MgCO_3$ content (%) | $CaCO_3$ content (%) | $MgCO_3$ amount (kt) | $CaCO_3$ amount (kt) | $MgCO_3$ $CO_2$ EF ($tCO_2$/t oxide) | $CaCO_3$ $CO_2$ EF ($tCO_2$/t oxide) | **$CO_2$ emissions (kt)** | Average $CO_2$ EF ($tCO_2$/t oxides) |
|---|---|---|---|---|---|---|---|---|---|
| **2005** | 29.891 | 10.75% | 12.79% | 3.213 | 3.823 | 0.522 | 0.440 | **3.359** | 0.477 |
| **2006** | 22.316 | 10.75% | 12.79% | 2.399 | 2.854 | 0.522 | 0.440 | **2.508** | 0.477 |
| **2007** | 23.854 | 10.75% | 12.79% | 2.564 | 3.051 | 0.522 | 0.440 | **2.681** | 0.477 |
| **2008** | 77.687 | 10.75% | 12.79% | 8.351 | 9.936 | 0.522 | 0.440 | **8.730** | 0.477 |
| **2009** | 19.814 | 10.75% | 12.79% | 2.13 | 2.534 | 0.522 | 0.440 | **2.230** | 0.477 |
| **2010** | 32.513 | 10.75% | 12.79% | 3.495 | 4.158 | 0.522 | 0.440 | **3.650** | 0.477 |
| **2011** | 38.914 | 10.75% | 12.79% | 4.183 | 4.977 | 0.522 | 0.440 | **4.370** | 0.477 |
| **2012** | 40.698 | 10.75% | 12.79% | 4.375 | 5.205 | 0.522 | 0.440 | **4.570** | 0.477 |
| **2013** | 49.705 | NA | NA | NA | NA | NA | NA | **4.772** | 0.096 |
| **2014** | 63.733 | NA | NA | NA | NA | NA | NA | **6.145** | 0.096 |

According to data from plant GHG annual report average $CO_2$ EF=0.096 $tCO_2$/t oxides already include $CaCO_3$ and $MgCO_2$ emission factors.

**4th bricks production plant**

The $CO_2$ emission estimation from 4$^{th}$ bricks production plant is rather complicated due to allowed approach in Latvia that Latvia's ETS operator can use different methodology for every year to estimate their $CO_2$ emissions.

After the review of 4$^{th}$ bricks production plant's application for GHG permit during ETS implementation in Latvia and the plant's annual GHG reports in 2005-2008 the plant's used methodology for $CO_2$ emission estimation in time series is inconsistent as methodology is changed four times during whole time series:

1. $CO_2$ emission for time period 2000-2004 was estimated by using used clay (with moisture content 23%) as an activity data and $CO_2$ emission factor for used clay – 0.0658 t $CO_2$/t used clay. Then $CO_2$ emission factor for dry clay is estimated by reducing it by 23% that gives emission factor – 0.050666 $tCO_2$/t used clay.
2. The plant for year 2005 is using the calculation method "A" – carbon input, from the MRG when calculation is based on the carbon input on each of the relevant raw materials. The content of $CaCO_3$ and $MgCO_3$ are determined in plant laboratories or stated in mineral deposits passport. Default $CO_2$ emission factors from the MRG for the $CaCO_3$ and $MgCO_3$ are used.
3. For years 2006 and 2007 the plant is using calculation method B – alkali earth oxides, from the MRG when calculation is based on the content of the CaO, MgO and other (earth) alkali.

4. For year 2008 plant is using the same calculation method A as for year 2005– carbon input, from the MRG when calculation is based on the carbon input on each of the relevant raw materials. Still Tier 1 emission factors from the MRG corresponding particular method are used when conservative value of 0.2 tonnes $CaCO_3$ (0.08794 tonnes of $CO_2$) per tonne of dry clay is applied for the calculation of the emission factor instead of results of analyses.

To make emission estimation more consistent the $CO_2$ emissions from 4th bricks production plant was recalculated:

1. for years 2000-2004 were recalculate by using the $CaCO_3$ and $MgCO_3$ content data reported by plant in its application for GHG permit when ETS was implemented in Latvia – $CaCO_3$ – 11.48%, and $MgCO_3$ – 1.8%, and using emission factors from MRG.
2. For year 2006-2007 the $CaCO_3$ and $MgCO_3$ content data were estimated from MgO and CaO content data corresponding molar mass of MgO, CaO and $CO_2$.
3. For year 2008 the same $CaCO_3$ and $MgCO_3$ content data as for 2007 was used in emission estimation as other information was not available (Table 8).

*Methods*

As bricks production plant is constantly changing used methodology to estimate their annual $CO_2$ emissions within ETS requirements, the emissions were recalculated using the most appropriate approach for the best result. As the $CaCO_3$ and $MgCO_3$ content data was available for 2000-2004 and then for 2005 but MgO and CaO content data was available for 2006-2007 it was decided to estimate $CO_2$ emissions using Calculation A method – carbon input from MRG [269].

The following equation was used to estimate $CO_2$ emissions from 4th bricks production plant:

$$CO_2 = \left(AD_{clay} \times AD_{CaCO_3} \times EF_{CaCO_3}\right) + \left(AD_{clay} \times AD_{MgCO_3} \times EF_{MgCO_3}\right)$$

*where:*

*$CO_2$ – $CO_2$ emissions from 4th bricks production plant (kt)*
*$AD_{clay}$ – activity data of used clay (kt)*
*$ADCaCO_3$ – $CaCO_3$ content in used clay (%)*
*$EFCaCO_3$ – $CaCO_3$ emission factor (kt/kt)*
*$ADMgCO_3$ – $MgCO_3$ content in used clay (%)*
*$EFMgCO_3$ – $MgCO_3$ emission factor (kt/kt)*

*Emission factors*

$CO_2$ emission factors for $CaCO_3$ and $MgCO_3$ – 0.44 and 0.522 for tonne $CO_2$ per tonne of carbonates respectively, were taken from Monitoring Reporting Guidelines[270] to recalculate the emissions.

*Activity data*

The plant reported that amount of carbonates ($CaCO_3$ and $MgCO_3$) in used clay is estimated according to chemical content of clay that was determined in Institute of Silicate Materials. For years 2005 the $CaCO_3$ and $MgCO_3$ content is taken from production plant's annual GHG

[269] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (pages 78,79)
[270] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 79)

report. For years 2006-2007 $CaCO_3$ and $MgCO_3$ data was estimated by taking into account used clay content data and its estimation parameters available from bricks production plant. For year 2008 that particular data was no available therefore the percentage amount of carbonates of year 2007 was used (Table 8).

According to production plant's application for GHG permit and annual GHG reports activity data of used raw materials is estimated using following equation:

$$AD_{raw} = \sum \left( AD_{bulk} \times M_{av} - M_{bulk} \times moisture/100 \right) - M_{chippings} - M_{tenisite}$$

*where:*
*$AD_{raw}$ – activity data of used raw materials – clay (kt)*
*$AD_{bulk}$ – amount of dried bulk materials (pieces)*
*$M_{av}$ – average mass (kt)*
*$M_{bulk}$ – mass of dried bulk materials loaded in furnace*
*moisture/100 – average moisture content of clay (%)*
*$M_{chippings}$ – mass of dried scobs (kt)*
*$M_{tenisite}$ – mass of tenisite (granulated burnt defectives of ceramics) (kt)*

Mass of chippings wasn't taken into account as it is biomass and is assumed as $CO_2$ neutral. Mass of tenisite – granulated burnt defectives of previously made ceramics that is folded into mass of clay to improve lasting of final production, is not taken into account as it is secondary process and during repeated burning the $CO_2$ emissions are not emitted.

**Table 8 Data and assumptions used for $CO_2$ emission estimation from 4th bricks production plant**

| | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| use of clay (kt) | NO | NO | 9.000 | 25.246 | 29.826 | 34.166 | 27.329 |
| $MgCO_3$ content (%) | NO | NO | 1.80% | 6.47% | 6.47% | 6.67% | 6.67% |
| $CaCO_3$ content (%) | NO | NO | 11.48% | 14.62% | 14.62% | 13.71% | 13.71% |
| $MgCO_3$ amount (kt) | NO | NO | 0.162 | 1.634 | 1.929 | 2.28 | 1.824 |
| $CaCO_3$ amount (kt) | NO | NO | 1.033 | 3.691 | 4.361 | 4.684 | 3.747 |
| $MgCO_3$ $CO_2$ EF ($tCO_2$/t oxide) | NO | NO | 0.522 | 0.522 | 0.522 | 0.522 | 0.522 |
| $CaCO_3$ $CO_2$ EF ($tCO_2$/t oxide) | NO | NO | 0.440 | 0.440 | 0.440 | 0.440 | 0.440 |
| $CO_2$ emissions (kt) | NO | NO | 0.539 | 2.477 | 2.926 | 3.251 | 2.601 |
| Average $CO_2$ EF ($tCO_2$/t oxides) | NO | NO | 0.451 | 0.465 | 0.465 | 0.467 | 0.467 |

In year 2009 the bricks production plant is not operating due to economic crisis that affected construction sector in Latvia where demand of the production sharply decreased. Still the non-operation of particular plant is assumed only temporary and it is prospective that plant will be operating again.

**5th bricks production plant**

In the bricks production plant's application for GHG permit during the implementation of ETS in Latvia in 2005 the $CO_2$ emission for time period 1993-2004 was estimated by using used clay as an activity data and $CO_2$ emission factor for used clay – 0.047 $tCO_2$/t used clay. After the review of the GHG report it was stated that plant is using the total used clay data as activity data instead of using particular CaO and MgO data even the MgO and CaO content is determined in Riga Technical University Institute of Silicate Materials for the clay used in particular plant. The plant's used an unknown source $CO_2$ EF for time series 1993-2004 therefore plant's reported data were recalculated according to available information and using the methodology from plant's latest reported annual GHG reports.

*Methods*

The particular bricks production plant is using Calculation method B – alkali earth oxides, from MRG[271]. According to MRG calcination of $CO_2$ is calculated based on the amounts of ceramics produced and the CaO, MgO and other (earth) alkali oxide contents of the ceramics.

Following equation from bricks production plant's annual GHG reports within EU ETS was used to estimate $CO_2$ emissions.

$$CO_2 = \sum\left(\left(AD_{raw} \times AD_{CaO,MgO} / 100\right) \times EF \times CF\right)$$

*where:*
*$CO_2$ – total $CO_2$ emissions from bricks production (kt)*
*$AD_{raw}$ – activity data of used raw materials – clay (kt)*
*$AD_{CaO,MgO}$% / 100 – CaO and/or MgO content in used raw materials (%)*
*EF – $CO_2$ emission factor of CaO and/or MgO (kt/kt)*
*CF – conversion factor*

For some years in bricks production also $CaCO_3$ was used as additive to clay for yellow bricks production. Following equation from plant's annual GHG reported was used to estimate $CO_2$ emissions from $CaCO_3$ use:

$$CO_2 = \sum\left(\left(AD_{raw} \times AD_{additive} / 100\right) \times 1.785 \times EF \times CF\right)$$

*where:*
*$CO_2$ – total $CO_2$ emissions from additive use (kt)*
*$AD_{raw}$ – activity data of used raw materials – clay (kt)*
*$AD_{additive}$% / 100 – CaO content in used raw materials (%)*
*1.785 – factor to estimate CaO from used $CaCO_3$ data*
*EF – $CO_2$ emission factor of CaO (kt/kt)*
*CF – conversion factor*

In latest years 2008-2013 the $CO_2$ emissions were estimated for different bulks of used clay therefore CaO and MgO content data for these bulks differs. Therefore the $CO_2$ emissions were estimated separately. In 2014 there is used EF=0.014 ($tCO_2$/t oxides) that already include $CO_2$ EFs from MgO and CaO (Table 9).

**Table 9 Data and assumptions used for $CO_2$ emission estimation from 5th bricks production plant**

| | Use of clay (kt) | MgO content (%) | CaO content (%) | MgO amount (kt) | CaO amount (kt) | MgO $CO_2$ EF ($tCO_2$/t oxide) | CaO $CO_2$ EF ($tCO_2$/t oxide) | $CaCO_3$ (additive) (kt) | **$CO_2$ emissions (kt)** | Average $CO_2$ EF ($tCO_2$/t oxides) |
|---|---|---|---|---|---|---|---|---|---|---|
| **1990** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **1995** | 107.38 | 1.43% | 10.39% | 1.536 | 11.152 | 1.092 | 0.785 | 0.000 | **10.431** | 0.822 |
| **2000** | 112.50 | 1.43% | 10.39% | 1.609 | 11.683 | 1.092 | 0.785 | 0.000 | **10.928** | 0.822 |
| **2005** | 88.29 | 0.39% | 1.75% | 0.344 | 1.545 | 1.092 | 0.785 | 0.000 | **1.589** | 0.841 |
| **2006** | 94.44 | 0.39% | 1.75% | 0.368 | 1.653 | 1.092 | 0.785 | 0.342 | **1.849** | 0.841 |

[271] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF *(page 80)*

| | Use of clay (kt) | MgO content (%) | CaO content (%) | MgO amount (kt) | CaO amount (kt) | MgO $CO_2$ EF ($tCO_2$/t oxide) | CaO $CO_2$ EF ($tCO_2$/t oxide) | $CaCO_3$ (additive) (kt) | **$CO_2$ emissions (kt)** | Average $CO_2$ EF ($tCO_2$/t oxides) |
|---|---|---|---|---|---|---|---|---|---|---|
| **2007** | 80.90 | 0.36% | 1.47% | 0.291 | 1.189 | 1.092 | 0.785 | 1.218 | **1.787** | 0.845 |
| **2008** | 26.32 | 1.23% | 0.32% | 0.324 | 0.084 | 1.092 | 0.785 | 0.000 | **1.594** | 1.029 |
| | 28.33 | 1.35% | 0.41% | 0.382 | 0.116 | 1.092 | 0.785 | | | 1.020 |
| | 28.82 | 1.26% | 0.38% | 0.363 | 0.110 | 1.092 | 0.785 | | | 1.021 |
| | 13.21 | 1.09% | 0.25% | 0.144 | 0.033 | 1.092 | 0.785 | | | 1.035 |
| **2009** | 1.05 | 1.09% | 0.25% | 0.011 | 0.003 | 1.092 | 0.785 | 0.000 | **0.647** | 1.035 |
| | 21.02 | 1.07% | 0.27% | 0.225 | 0.057 | 1.092 | 0.785 | | | 1.030 |
| | 22.05 | 1.16% | 0.27% | 0.256 | 0.060 | 1.092 | 0.785 | | | 1.034 |
| | 1.19 | 1.12% | 0.23% | 0.013 | 0.003 | 1.092 | 0.785 | | | 1.040 |
| **2010** | 0.82 | 1.12% | 0.23% | 0.009 | 0.002 | 1.092 | 0.785 | 1.019 | **1.396** | 1.040 |
| | 21.05 | 1.23% | 0.26% | 0.259 | 0.055 | 1.092 | 0.785 | | | 1.038 |
| | 21.15 | 1.13% | 0.24% | 0.239 | 0.051 | 1.092 | 0.785 | | | 1.038 |
| | 20.80 | 1.16% | 0.28% | 0.241 | 0.058 | 1.092 | 0.785 | | | 1.032 |
| **2011** | 17.72 | 1.12% | 0.23% | 0.198 | 0.041 | 1.092 | 0.785 | 2.875 | **2.638** | 1.040 |
| | 26.51 | 1.23% | 0.26% | 0.326 | 0.069 | 1.092 | 0.785 | | | 1.038 |
| | 25.05 | 1.13% | 0.24% | 0.283 | 0.060 | 1.092 | 0.785 | | | 1.038 |
| | 24.07 | 1.16% | 0.28% | 0.279 | 0.067 | 1.092 | 0.785 | | | 1.032 |
| **2012** | 21.17 | 1.12% | 0.23% | 0.237 | 0.049 | 1.092 | 0.785 | 2.465 | **2.287** | 1.040 |
| | 20.83 | 1.23% | 0.26% | 0.256 | 0.054 | 1.092 | 0.785 | | | 1.038 |
| | 18.59 | 1.13% | 0.24% | 0.210 | 0.045 | 1.092 | 0.785 | | | 1.038 |
| | 21.41 | 1.16% | 0.28% | 0.248 | 0.060 | 1.092 | 0.785 | | | 1.032 |
| **2013** | 20.75 | 1.02% | 0.25% | 0.212 | 0.052 | 1.092 | 0.785 | 5.863 | **3.744** | 1.032 |
| | 20.28 | 1.22% | 0.39% | 0.247 | 0.079 | 1.092 | 0.785 | | | 1.018 |
| | 18.48 | 1.20% | 0.30% | 0.222 | 0.055 | 1.092 | 0.785 | | | 1.031 |
| | 20.60 | 1.20% | 0.03% | 0.247 | 0.006 | 1.092 | 0.785 | | | 1.085 |
| **2014** | 76.93 | NA | NA | NA | NA | NA | NA | 6.932 | **4.163** | 0.014 |

*Emission factors*

$CO_2$ emission factors for CaO and MgO – 0.785 and 1.092 for tonne $CO_2$ per tonne of oxide respectively, were taken from MRG[272]. In plant's application to GHG permit unknown source emission factor was used therefore the data for 1993-2004 was recalculated using emission factor from MRG.

*Activity data*

According to production plant's application for GHG permit and annual GHG reports activity data of used raw materials is estimated using following equation:

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[272] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF *(page 81)*

$$AD_{raw} = \sum \left( AD_{bulk} \times M_{av} - M_{bulk} \times moisture/100 \right)$$

*where:*
*$AD_{raw}$ – activity data of used raw materials – clay (kt)*
*$AD_{bulk}$ – amount of dried bulk materials (pieces)*
*$M_{av}$ – average mass (kt)*
*$M_{bulk}$ – mass of dried bulk materials*
*moisture/100 – content of moisture (%)*

Content of CaO and MgO in used clay is determined in independent certified laboratory taking analysis of used clay. Used additives – $CaCO_3$ (limestone flour) is weighted in production plant before addition to clay.

For years 1993-2004 the CaO and MgO content was unknown as such laboratory measurements were not done before EU ETS implementation requirements. The CaO and MgO content data was determined only in the end of 2003. This particular amount was then used for all years in time period 1993-2004 as other data was not available.

## A.3.7 Agriculture

### Manure Management Systems distribution, 1990-2014

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dairy cows** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.12 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 |
| Solid storage | 0.83 | 0.83 | 0.82 | 0.82 | 0.81 | 0.81 | 0.80 | 0.79 | 0.78 | 0.77 | 0.76 | 0.72 | 0.72 | 0.71 | 0.70 | 0.70 | 0.69 | 0.67 | 0.64 | 0.62 | 0.60 | 0.58 | 0.56 | 0.54 | 0.53 |
| Liquid/ Slurry | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 | 0.10 | 0.11 | 0.12 | 0.13 | 0.18 | 0.19 | 0.19 | 0.20 | 0.21 | 0.22 | 0.24 | 0.27 | 0.29 | 0.27 | 0.28 | 0.25 | 0.24 | 0.27 |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 0.04 | 0.05 | 0.11 | 0.14 | 0.13 |
| **Sheep** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| Solid storage | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Goats** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| Solid storage | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Horses** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| Solid storage | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Sows and boars** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Solid storage | 0.72 | 0.71 | 0.69 | 0.68 | 0.66 | 0.64 | 0.62 | 0.60 | 0.57 | 0.55 | 0.53 | 0.48 | 0.44 | 0.40 | 0.37 | 0.33 | 0.30 | 0.28 | 0.25 | 0.23 | 0.21 | 0.18 | 0.16 | 0.14 | 0.12 |
| Liquid/ Slurry | 0.28 | 0.29 | 0.31 | 0.32 | 0.34 | 0.36 | 0.38 | 0.41 | 0.43 | 0.45 | 0.47 | 0.52 | 0.56 | 0.60 | 0.63 | 0.67 | 0.70 | 0.72 | 0.75 | 0.77 | 0.71 | 0.71 | 0.61 | 0.56 | 0.52 |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 0.08 | 0.11 | 0.24 | 0.30 | 0.36 |

| | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Piglets** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Solid storage | 0.72 | 0.71 | 0.70 | 0.68 | 0.67 | 0.65 | 0.63 | 0.60 | 0.58 | 0.56 | 0.53 | 0.49 | 0.45 | 0.41 | 0.37 | 0.34 | 0.31 | 0.28 | 0.26 | 0.23 | 0.21 | 0.19 | 0.16 | 0.14 | 0.12 |
| Liquid/ Slurry | 0.28 | 0.29 | 0.30 | 0.32 | 0.33 | 0.35 | 0.38 | 0.40 | 0.42 | 0.45 | 0.47 | 0.51 | 0.55 | 0.59 | 0.63 | 0.67 | 0.69 | 0.72 | 0.74 | 0.77 | 0.71 | 0.71 | 0.60 | 0.56 | 0.52 |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 0.08 | 0.11 | 0.23 | 0.30 | 0.36 |
| **Fattening and young breeding pigs** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Solid storage | 0.71 | 0.70 | 0.68 | 0.67 | 0.65 | 0.63 | 0.61 | 0.58 | 0.56 | 0.54 | 0.52 | 0.47 | 0.43 | 0.39 | 0.35 | 0.32 | 0.29 | 0.27 | 0.24 | 0.22 | 0.20 | 0.17 | 0.15 | 0.13 | 0.11 |
| Liquid/ Slurry | 0.29 | 0.30 | 0.32 | 0.33 | 0.35 | 0.37 | 0.39 | 0.42 | 0.44 | 0.46 | 0.49 | 0.53 | 0.57 | 0.61 | 0.65 | 0.68 | 0.71 | 0.73 | 0.76 | 0.78 | 0.72 | 0.72 | 0.61 | 0.56 | 0.52 |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 0.09 | 0.11 | 0.24 | 0.31 | 0.36 |
| **Laying hens** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Solid storage | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.87 | 0.84 | 0.71 | 0.63 | 0.46 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 0.10 | 0.13 | 0.26 | 0.35 | 0.51 |
| **Broilers** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Solid storage | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Turkeys** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| Solid storage | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Ducks** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Solid storage | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Geese** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| Solid storage | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Rabbits** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Solid storage | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Fur animals** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Solid storage | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Deer** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Solid storage | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| ***Dairy cattle calves under 1 year*** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 |
| Solid storage | 0.88 | 0.88 | 0.88 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.91 | 0.91 | 0.88 | 0.88 | 0.84 | 0.81 | 0.82 |
| Liquid/ Slurry | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 0.03 | 0.04 | 0.08 | 0.11 | 0.10 |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Beef cattle calves under 1 year*** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| Solid storage | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| Liquid/ Slurry | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| ***Dairy cow young cattle, aged 1-2 years*** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 |
| Solid storage | 0.88 | 0.88 | 0.88 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.91 | 0.91 | 0.88 | 0.88 | 0.84 | 0.81 | 0.82 |
| Liquid/ Slurry | NO | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 0.03 | 0.04 | 0.08 | 0.11 | 0.10 |
| ***Beef young cattle, aged 1-2 years*** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| Solid storage | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| Liquid/ Slurry | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| ***Bulls over 2 year*** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| Solid storage | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| ***Heifers over 2 years*** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| Solid storage | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Other cows over 2 year* | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pasture/Range/Paddock | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| Solid storage | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| Liquid/ Slurry | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Anaerobic digester | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

# *Annex 4: National energy balance of Latvia in 2014 (TJ)*

| | Oil products - total | Shale oil | Liquefied petroleum gas | Motor and aviation petrol | Petrol type jet fuel | Kerosene type jet fuel | Kerosene | Diesel oil (oven fuel inclusive) | Residual (heavy) fuel oils | White spirit | Lubricants | Oil bitumen | Paraffin waxes | Other oil products | Used oils | Coal | Peat | Peat briquettes | Coke oven coke | Natural gas | Fuelwood | Used tires | Municipal waste for heating | Charcoal | Bioethanol | Biodiesel | Landfill gas | Sewage sludge gas | Other biogas | Straw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NCV** | | 39.35 | 45.54 | 43.97 | 43.21 | 43.21 | 43.2 | 42.49 | 40.6 | 41.86 | 41.86 | 41.86 | 41.86 | 41.86 | 29.23 | 24.16 | 10.05 | 15.49 | 26.79 | 34.57 | | 27.98 | 17.05 | 30 | 0.03 | 0.04 | 19.02 | 20.49 | 19.02 | 14.4 |
| **Production** | | | | | | | | | | | | | | | | | 50 | | | | 85567 | | | | | 2788 | 355 | 93 | 2688 | 99 |
| **Recycled products** | 29 | | | | | | | | | | | | | | 29 | | | | | | | 168 | 171 | | | | | | | |
| **Imports** | 89374 | 79 | 8971 | 9491 | | 4796 | 43 | 58254 | 41 | 42 | 1426 | 3014 | 335 | 2882 | | 2061 | | | 0 | 32733 | 2454 | 196 | 2046 | 60 | 259 | 380 | | | | |
| **Imported for bunkering** | 9712 | | | | | | | 2932 | 6780 | | | | | | | | | | | | | | | | | | | | | |
| **Exports** | 35007 | 79 | 4645 | 912 | | 173 | 43 | 25027 | 487 | | 836 | | | 2805 | | 145 | | | | | 30318 | | | 360 | 11 | 2454 | | | | |
| **Bunkering** | 9712 | | | | | | | 2932 | 6780 | | | | | | | | | | | | | | | | | | | | | |
| **Interproduct transfers** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Stock changes** | 5225 | | -91 | 791 | | | | 4122 | 487 | | 42 | -84 | | -42 | | 557 | -20 | 5 | | 12653 | -1782 | | 153 | | 9 | 27 | | | | |
| **Statistical difference** | 31 | | | -352 | | | | 383 | | | | | | | | | | | | | | | | | | | | | | |
| **Gross energy consumption** | 59652 | | 4235 | 9018 | | 4623 | | 37732 | 41 | 42 | 632 | 2930 | 335 | 35 | 29 | 2473 | 30 | 5 | 0 | 45386 | 55921 | 364 | 2370 | -300 | 257 | 741 | 355 | 93 | 2688 | 99 |
| **Transformation** | -51 | | -7 | | | | | -34 | -10 | | | | | | | -244 | | | | -30263 | -13694 | | | 390 | | | -214 | -93 | -2473 | -23 |
| **electricity plants** | | | | | | | | | | | | | | | | | | | | | -41 | | | | | | | | | |
| **public CHP** | -10 | | | | | | | -10 | | | | | | | | -167 | | | | -26460 | -6575 | | | | | | -31 | -93 | -1842 | |
| **autoproducer CHP** | | | | | | | | | | | | | | | | | | | | -506 | -481 | | | | | | -183 | | -631 | |
| **public heat plants** | -23 | | -1 | | | | | -12 | -10 | | | | | | | -8 | | | | -2580 | -4568 | | | | | | | | | |
| **autoproducer heat plants** | -18 | | -6 | | | | | -12 | | | | | | | | -69 | | | | -717 | -1245 | | | | | | | | | -23 |
| **production of peat briquettes** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **charcoal production** | | | | | | | | | | | | | | | | | | | | | -784 | | | 390 | | | | | | |

| | Oil products - total | Shale oil | Liquefied petroleum gas | Motor and aviation petrol | Petrol type jet fuel | Kerosene type jet fuel | Kerosene | Diesel oil (oven fuel inclusive) | Residual (heavy) fuel oils | White spirit | Lubricants | Oil bitumen | Paraffin waxes | Other oil products | Used oils | Coal | Peat | Peat briquettes | Coke oven coke | Natural gas | Fuelwood | Used tires | Municipal waste for heating | Charcoal | Bioethanol | Biodiesel | Landfill gas | Sewage sludge gas | Other biogas | Straw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Energy sector** | 286 | | | | | | | 286 | | | | | | | | | | | | 830 | | | | | | | | | | |
| **Losses** | | | | | | | | | | | | | | | | | | | | 588 | | | | | | | | | | |
| **Final consumption** | 59315 | | 4228 | 9018 | | 4623 | | 37412 | 31 | 42 | 632 | 2930 | 335 | 35 | 29 | 2229 | 30 | 5 | 0 | 13705 | 42227 | 364 | 2370 | 90 | 257 | 741 | 141 | | 215 | 76 |
| **Transport** | 44951 | | 2646 | 8621 | | 4623 | | 28468 | | | 593 | | | | | | | | | | | | | | 257 | 666 | | | | |
| **international air transport** | 4580 | | | | | 4580 | | | | | | | | | | | | | | | | | | | | | | | | |
| **domestic air transport** | 47 | | | 4 | | 43 | | | | | | | | | | | | | | | | | | | | | | | | |
| **road transport** | 37206 | | 2646 | 8617 | | | | 25409 | | | 534 | | | | | | | | | | | | | | 257 | 583 | | | | |
| **rail transport** | 2948 | | | | | | | 2889 | | | 59 | | | | | | | | | | | | | | | 83 | | | | |
| **inland shipping** | 170 | | | | | | | 170 | | | | | | | | | | | | | | | | | | | | | | |
| **pipeline transport** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Industry and construction** | 5590 | | 423 | 43 | | | | 1722 | 31 | 42 | | 2930 | 335 | 35 | 29 | 1336 | 20 | 4 | 0 | 5028 | 14792 | 364 | 2370 | | | 4 | | | 32 | |
| **manufacture of metals** | | | | | | | | | | | | | | | | | | | | 13 | | | | | | | | | | |
| **manufacture of chemicals and chemical products** | 202 | | 144 | 1 | | | | 15 | | 42 | | | | | | | 10 | 1 | | 309 | 275 | | | | | 1 | | | 30 | |
| **manufacture of other fabricated metal products** | | | | | | | | | | | | | | | | | | | | 72 | | | | | | | | | | |
| **manufacture of other non-metallic mineral products** | 275 | | | | | | | 275 | | | | | | | | 1254 | | | | 1352 | | 364 | 2370 | | | 3 | | | | |
| **manufacture of transport equipment** | 37 | | 11 | | | | | 26 | | | | | | | | | | | 0 | 54 | 0 | | | | | | | | | |
| **machinery** | 29 | | 15 | | | | | 14 | | | | | | | | 24 | | 2 | | 235 | 123 | | | | | | | | | |
| **mining and quarrying** | 194 | | | 1 | | | | 193 | | | | | | | | | 10 | 1 | | 43 | 0 | | | | | | | | | |
| **manufacture of** | 411 | | 160 | 4 | | | | 152 | 31 | | | | | 35 | 29 | 24 | | | | 1627 | 452 | | | | | | | | 2 | |

| | Oil products - total | Shale oil | Liquefied petroleum gas | Motor and aviation petrol | Petrol type jet fuel | Kerosene type jet fuel | Kerosene | Diesel oil (oven fuel inclusive) | Residual (heavy) fuel oils | White spirit | Lubricants | Oil bitumen | Paraffin waxes | Other oil products | Used oils | Coal | Peat | Peat briquettes | Coke oven coke | Natural gas | Fuelwood | Used tires | Municipal waste for heating | Charcoal | Bioethanol | Biodiesel | Landfill gas | Sewage sludge gas | Other biogas | Straw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **food products, beverages and tobacco** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **manufacture of paper and paper products** | 6 | | 4 | | | | | 2 | | | | | | | | | | | | 97 | 3 | | | | | | | | | |
| **manufacture of wood and of products of wood and cork** | 524 | | 25 | 13 | | | | 360 | | | | | 126 | | | | | | | 535 | 13747 | | | | | | | | | |
| **construction** | 3642 | | 52 | 23 | | | | 637 | | | | 2930 | | | | 24 | | | | 407 | 51 | | | | | | | | | |
| **manufacture of textiles** | 3 | | | | | | | 3 | | | | | | | | 10 | | | | 219 | 0 | | | | | | | | | |
| **manufacture of other products** | 267 | | 12 | 1 | | | | 45 | | | | | 209 | | | | | | | 65 | 141 | | | | | | | | | |
| **Other sectors** | 8774 | | 1159 | 354 | | | | 7222 | | | 39 | | | | | 893 | 10 | 1 | | 8677 | 27435 | | | 90 | | 71 | 141 | | 183 | 76 |
| **other consumers - commercial and public sector** | 2111 | | 155 | 44 | | | | 1912 | | | | | | | | 338 | 10 | 1 | | 3803 | 3462 | | | | | 12 | 141 | | | 30 |
| **households** | 2283 | | 957 | 264 | | | | 1062 | | | | | | | | 531 | | | | 4252 | 23690 | | | 90 | | | | | | |
| **crop and animal production, hunting and related service activities; forestry and logging** | 4078 | | 45 | 44 | | | | 3951 | | | 38 | | | | | 24 | | 0 | | 622 | 276 | | | | | 59 | | | 183 | 46 |
| **fishing** | 302 | | 2 | 2 | | | | 297 | | | 1 | | | | | | | | | | 7 | | | | | | | | | |

## *Annex 5: Other*

Additional information on CSB Integrated Statistical Data Management System (ISDMS)

ISDMS contents:

Following business application software modules are covering and supporting all phases of the statistical data processing:

Core metadata base module – the key part of the system ensures metadata collection and storage, defines all entire system processes starting from data collection and ending with output reports preparation. All System software modules are linked with the Core Metadata module.

Registers module – ensure system users with the full range of respondents data.

Data entry and validation module – generates date entry and validation applications, executes validation and data editing processes and storage clean data sets in the Micro Data Base.

Web based data collection module – ensures electronic data collection via Web.

Data aggregation module – ensures data aggregation on different conditions and storage of the aggregated data sets in the Macro Data Base.

Data analysis module – via micro data export to MS Excel and/or Access ensures data analysis processes, MS OLAP tools are available for data analysis as well.

Data dissemination module – ensures data storage for publication at CSB web.

User’s administration module – administrates user roles and rights.

ISDMS advantages:

- Standardized data entry, processing and storage procedures => process oriented data processing.
- Centralized processing and storage of all types of statistical data, including metadata, by using data warehouse technologies and OLAP tools.
- The system is connected to Business Register => direct respondent basic data retrieval and updating.
- Special import and export procedure is created for data exchange with other systems.

A link with PC Axis is created for electronic data dissemination

## *Annex 6: Supplementary information under Article 6., 12., 17*

In 2015 there are no Joint Implementation Project (Article 6) and no Clean Development Mechanism (Article 12) projects in Latvia.

There are no specific limitation rules for the operators and/or person accounts in Latvia's of holding of Kyoto protocol units with exception of AAUs that could be held only in the National Holding Account.

The list given below includes the legal entities that have active accounts in Latvia's ETR at the end of 2015 and doesn't include accounts that were closed after the compliance period 30/04/2015.

**Legal entities authorized to participate in the mechanisms under Articles 6, 12 and 17 of the Kyoto Protocol**

| Legal entities authorized to participate in the mechanisms under Article 6, 12 and 17 of the Kyoto Protocol) | Account ID | Role |
|---|---|---|
| A/S "Olaines udens un siltums" | LV-HOLDING_ACCOUNT-5012073-0-4 | Latvia's ETR operator (obligatory participation) |
| Pasvaldibas SIA "Ventspils siltums" | LV-HOLDING_ACCOUNT-5012074-0-96 | Latvia's ETR operator (obligatory participation) |
| Pasvaldibas SIA "Ventspils siltums" | LV-HOLDING_ACCOUNT-5012075-0-91 | Latvia's ETR operator (obligatory participation) |
| AS "Latvenergo" TEC-1 | LV-HOLDING_ACCOUNT-5012078-0-76 | Latvia's ETR operator (obligatory participation) |
| AS "Latvenergo" TEC-2 | LV-HOLDING_ACCOUNT-5012079-0-71 | Latvia's ETR operator (obligatory participation) |
| SIA "Fortum Jelgava" | LV-HOLDING_ACCOUNT-5012080-0-66 | Latvia's ETR operator (obligatory participation) |
| SIA "Fortum Jelgava" | LV-HOLDING_ACCOUNT-5012081-0-61 | Latvia's ETR operator (obligatory participation) |
| SIA "Livanu siltums" | LV-HOLDING_ACCOUNT-5012084-0-46 | Latvia's ETR operator (obligatory participation) |
| SIA "Aizkraukles siltums" | LV-HOLDING_ACCOUNT-5012085-0-41 | Latvia's ETR operator (obligatory participation) |
| A/S "Rigas siltums" katlu maja Gobas iela 33a | LV-HOLDING_ACCOUNT-5012086-0-36 | Latvia's ETR operator (obligatory participation) |
| A/S "Rigas siltums" siltumcentrale Daugavgriva | LV-HOLDING_ACCOUNT-5012087-0-31 | Latvia's ETR operator (obligatory participation) |
| A/S "Rigas siltums" siltumcentrale Vecmilgravis | LV-HOLDING_ACCOUNT-5012088-0-26 | Latvia's ETR operator (obligatory participation) |
| A/S "Rigas siltums" siltumcentrale Ziepniekkalns | LV-HOLDING_ACCOUNT-5012089-0-21 | Latvia's ETR operator (obligatory participation) |
| A/S "Rigas siltums" iecirknis Zasulauks | LV-HOLDING_ACCOUNT-5012090-0-16 | Latvia's ETR operator (obligatory participation) |
| A/S "Rigas siltums" siltumcentrale Imanta | LV-HOLDING_ACCOUNT-5012091-0-11 | Latvia's ETR operator (obligatory participation) |
| SIA "Dobeles energija" | LV-HOLDING_ACCOUNT-5012092-0-6 | Latvia's ETR operator (obligatory participation) |
| Ogres novada PA "Ogres namsaimnieks" | LV-HOLDING_ACCOUNT-5012093-0-98 | Latvia's ETR operator (obligatory participation) |
| SIA "Wesemann –Sigulda" | LV-HOLDING_ACCOUNT-5012094-0-93 | Latvia's ETR operator (obligatory participation) |
| SIA "Jurmalas siltums" Dubulti | LV-HOLDING_ACCOUNT-5012096-0-83 | Latvia's ETR operator (obligatory participation) |
| SIA "Jurmalas siltums" Kauguri | LV-HOLDING_ACCOUNT-5012097-0-78 | Latvia's ETR operator (obligatory participation) |
| A/S "Cesvaines piens" | LV-HOLDING_ACCOUNT-5012100-0-63 | Latvia's ETR operator (obligatory participation) |
| SIA "Rigas laku un krasu rupnica" | LV-HOLDING_ACCOUNT-5012101-0-58 | Latvia's ETR operator (obligatory participation) |

| Legal entities authorized to participate in the mechanisms under Article 6, 12 and 17 of the Kyoto Protocol) | Account ID | Role |
|---|---|---|
| A/s "Putnu fabrika Kekava"" | LV-HOLDING_ACCOUNT-5012102-0-53 | Latvia's ETR operator (obligatory participation) |
| A/S "Rigas kugu buvetava" | LV-HOLDING_ACCOUNT-5012103-0-48 | Latvia's ETR operator (obligatory participation) |
| A/S "BLB Baltijas Terminals" | LV-HOLDING_ACCOUNT-5012104-0-43 | Latvia's ETR operator (obligatory participation) |
| SIA "Kraslavas 781ame" | LV-HOLDING_ACCOUNT-5012106-0-33 | Latvia's ETR operator (obligatory participation) |
| SIA "Cesu siltumtikli" | LV-HOLDING_ACCOUNT-5012108-0-23 | Latvia's ETR operator (obligatory participation) |
| PAS "Daugavpils siltumtikli" SC3 | LV-HOLDING_ACCOUNT-5012110-0-13 | Latvia's ETR operator (obligatory participation) |
| PAS "Daugavpils siltumtikli" SC1 | LV-HOLDING_ACCOUNT-5012111-0-8 | Latvia's ETR operator (obligatory participation) |
| PAS "Daugavpils siltumtikli" SC2 | LV-HOLDING_ACCOUNT-5012112-0-3 | Latvia's ETR operator (obligatory participation) |
| A/S "Ligija teks" | LV-HOLDING_ACCOUNT-5012113-0-95 | Latvia's ETR operator (obligatory participation) |
| SIA "Jekabpils siltums" | LV-HOLDING_ACCOUNT-5012114-0-90 | Latvia's ETR operator (obligatory participation) |
| A/S "Valmieras piens" | LV-HOLDING_ACCOUNT-5012117-0-75 | Latvia's ETR operator (obligatory participation) |
| SIA "Lauma Fabrics" | LV-HOLDING_ACCOUNT-5012119-0-65 | Latvia's ETR operator (obligatory participation) |
| SIA "Liepajas energija" | LV-HOLDING_ACCOUNT-5012120-0-60 | Latvia's ETR operator (obligatory participation) |
| SIA "Liepajas energija" | LV-HOLDING_ACCOUNT-5012121-0-55 | Latvia's ETR operator (obligatory participation) |
| A/S "Preilu siers" | LV-HOLDING_ACCOUNT-5012122-0-50 | Latvia's ETR operator (obligatory participation) |
| SIA "Ogres Trikotaza" | LV-HOLDING_ACCOUNT-5012123-0-45 | Latvia's ETR operator (obligatory participation) |
| SIA "Salaspils siltums" | LV-HOLDING_ACCOUNT-5012124-0-40 | Latvia's ETR operator (obligatory participation) |
| A/S "Latvijas finieris" rupnica "Furniers" | LV-HOLDING_ACCOUNT-5012125-0-35 | Latvia's ETR operator (obligatory participation) |
| A/S "Latvijas Finieris" rupnica "Lignums" | LV-HOLDING_ACCOUNT-5012126-0-30 | Latvia's ETR operator (obligatory participation) |
| SIA "Sabiedriba Marupe" | LV-HOLDING_ACCOUNT-5012127-0-25 | Latvia's ETR operator (obligatory participation) |
| A/S "Ventbunkers" | LV-HOLDING_ACCOUNT-5012129-0-15 | Latvia's ETR operator (obligatory participation) |
| SIA "Papirfabrika Ligatne" | LV-HOLDING_ACCOUNT-5012130-0-10 | Latvia's ETR operator (obligatory participation) |
| SIA "Saulkalne S" | LV-HOLDING_ACCOUNT-5012131-0-5 | Latvia's ETR operator (obligatory participation) |
| SIA "Brocenu keramika" | LV-HOLDING_ACCOUNT-5012132-0-97 | Latvia's ETR operator (obligatory participation) |
| A/S "Valmieras stikla skiedra" | LV-HOLDING_ACCOUNT-5012133-0-92 | Latvia's ETR operator (obligatory participation) |
| LODE SIA, Liepas plant | LV-HOLDING_ACCOUNT-5012135-0-82 | Latvia's ETR operator (obligatory participation) |
| A/S "KVV Liepajas metalurgs" | LV-HOLDING_ACCOUNT-5012137-0-72 | Latvia's ETR operator (obligatory participation) |
| LODE SIA, Ane plant | LV-HOLDING_ACCOUNT-5012141-0-52 | Latvia's ETR operator (obligatory participation) |
| SIA "Olaines kimiska rupnica "BIOLARS"" | LV-HOLDING_ACCOUNT-5012154-0-84 | Latvia's ETR operator (obligatory participation) |
| SIA "Bolderaja Ltd" | LV-HOLDING_ACCOUNT-5012166-0-24 | Latvia's ETR operator (obligatory participation) |
| SIA "Juglas jauda" | LV-HOLDING_ACCOUNT-5012169-0-9 | Latvia's ETR operator (obligatory participation) |
| A/S "Valmieras Energija" Rigas iela 25 | LV-HOLDING_ACCOUNT-5012171-0-96 | Latvia's ETR operator (obligatory participation) |

| **Legal entities authorized to participate in the mechanisms under Article 6, 12 and 17 of the Kyoto Protocol)** | **Account ID** | **Role** |
|---|---|---|
| A/S “Valmieras Energija” Dzelzcela iela 7 | LV-HOLDING_ACCOUNT-5012172-0-91 | Latvia’s ETR operator (obligatory participation) |
| A/S “Latvijas Gaze” | LV-HOLDING_ACCOUNT-5012173-0-86 | Latvia’s ETR operator (obligatory participation) |
| SIA “Fortum Jelgava” | LV-HOLDING_ACCOUNT-5012175-0-76 | Latvia’s ETR operator (obligatory participation) |
| SIA “Rigens” | LV-HOLDING_ACCOUNT- 5012177-0-66 | Latvia’s ETR operator (obligatory participation) |
| SIA "Jaunpagasts Plus" Jaunpagasta spirta rupnica | LV-HOLDING_ACCOUNT-5012179-0-56 | Latvia's ETR operator (obligatory participation) |
| A/S "Rezeknes Siltumtikli" Atbrivosanas aleja 155a | LV-HOLDING_ACCOUNT-5012180-0-51 | Latvia's ETR operator (obligatory participation) |
| A/S "Rezeknes Siltumtikli" N.Rancana iela 5 | LV-HOLDING_ACCOUNT-5012181-0-46 | Latvia's ETR operator (obligatory participation) |
| A/S "Rezeknes Siltumtikli" Meza iela 1 | LV-HOLDING_ACCOUNT-5012182-0-41 | Latvia's ETR operator (obligatory participation) |
| SIA "Gamma - A" | LV-HOLDING_ACCOUNT-5012184-0-31 | Latvia's ETR operator (obligatory participation) |
| SIA "CEMEX" | LV-HOLDING_ACCOUNT-5012185-0-26 | Latvia's ETR operator (obligatory participation) |
| SIA “KNAUF” | LV-HOLDING_ACCOUNT-5020444-0-53 | Latvia's ETR operator (obligatory participation) |
| A/S "Olainfarm" | LV-HOLDING_ACCOUNT-5023045-0-46 | Latvia's ETR operator (obligatory participation) |
| SIA "KD LATGALE" | LV-HOLDING_ACCOUNT- 5021816-0-62 | Legal person |
| Smartlynx Airlines | LV-HOLDING_ACCOUNT-5000042-0-19 | Latvia's ETR aircraft operator (obligatory participation) |
| A/S AirBaltic Corporation"" | LV-HOLDING_ACCOUNT-5000081-0-18 | Latvia's ETR aircraft operator (obligatory participation) |